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464C-JWH-5063
24 January 2001

BOEING

Mr. Jerome Johnson
U.S. Environmental Protection Agency Region VII
901 North Fifth Street
Kansas City, Kansas 66101

Enclosure: Remedial Action Plan for Former Boeing Fabrication Operations Facility, St. Louis, Missouri

Dear Mr. Johnson;

Enclosed are two copies of the Remedial Action Plan. This document sets forth additional investigation tasks and planned remedial actions for the Building 27 naval Weapons Industrial Plant (NWIRP), as well as the other areas of the Tract I complex. This document is provided in accordance with the corrective Action Conditions of the Hazardous Waste Management Facility Permit # MOD 000 818 963.

Please contact me should you need additional information.

Sincerely,

Joe Haake

Joseph W. Haake, Group Manager
Environmental and Hazardous Materials Services
Dept. 464C, Bldg. 220, Mailcode S221-1400
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JAN 29 2001

RCAP

Remedial Action Plan
for
Former Boeing Fabrication Operations Facility
St. Louis, Missouri

Prepared for:
The Boeing Company
St. Louis, Missouri

Prepared by:
Harding ESE (formerly Environmental Science & Engineering, Inc.)
St. Louis, Missouri

January 19, 2001

Harding ESE Project No. 510098.0300

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List of Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
CALM	Cleanup Levels for Missouri
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSF	carcinogenic slope factor
COC	constituent of concern
DCE	dichloroethene
DQL	Data Quality Level
DQO	data quality objective
EQ	Ecotoxicity Quotient
ET	Ecotox Threshold
ESA	Environmental Site Assessment
ft bls	feet below land surface
FR	Federal Register
HASP	Health and Safety Plan
ID	internal diameter
ITL	investigation threshold level
IWTP	Industrial Wastewater Treatment Plant
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDNR	Missouri Department of Natural Resources
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram
MIBK	methyl isobutyl ketone
NCP	National Contingency Plan
PAH	polynuclear aromatic hydrocarbon
PCE	perchloroethylene
ppb	parts per billion
ppm	parts per million
PRG	Preliminary Remediation Goal
PRO	Preliminary Remediation Objective
QA	quality assurance
QAPP	Quality Assurance Project Plan
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act

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RFA	RCRA Facility Assessment
RFD	Reference Dose
RFI	RCRA Facility Investigation
SLAPS	St. Louis Airport Site
SSL	Soil Screening Levels
SW	solid waste
SWMU	solid waste management unit
TCE	trichloroethene
UCL95	Upper 95 percent confidence level
UCL_{95}	upper 95 percent confidence levels
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VSI	Visual Site Inspection
°C	degrees Celsius
μg/kg	microgram per kilogram
μs/cm	unit of conductivity

1.0 Introduction

This document represents the Remedial Action Plan (RAP) for additional investigation tasks and planned remedial actions that will be completed at The Boeing Company's former Fabrication Operations Facility in St. Louis, Missouri (Facility). This RAP supplements the previous Phase 2 Environmental Site Assessment (ESA) activities and reports completed by Harding ESE (formerly known as ESE [Environmental Science & Engineering, Inc.]) for Boeing from July-November 2000.

1.1 Purpose

The initial purpose of this RAP is to present supplemental field activities (Phase 2C ESA) for characterizing environmental conditions at the Facility. This document and the previously prepared support plans describe the proposed technical scope of work and administrative/implementation approach for completion of the Facility investigation and reporting activities. These Phase 2C ESA activities will be implemented in conjunction with two associated support plans including a Quality Assurance Project Plan (QAPP) and a Health and Safety Plan (HASP) which were previously prepared by Golder Associates.

The second purpose of this RAP is to identify and conceptually evaluate potential remedial alternatives for addressing releases at the Facility. The RAP culminates with the selection of a remedial alternative for development in the subsequent Corrective Measures Implementation (CMI) process. Detailed development and design of the selected alternative from this RAP will be performed in the CMI. The purpose of the CMI is to design, construct, operate, maintain, and monitor the selected remedial alternative.

This RAP will be submitted to MDNR for review and formal approval.

1.2 RAP Organization

This RAP is divided into ten sections of text. A brief description of each section is presented below.

Section 1.0, **Introduction**, describes the purpose and content of this RAP.

Section 2.0, **Project Management**, references the various management and administrative issues associated with the project.

Section 3.0, **Description of Current Conditions**, provides a summary of current Facility conditions.

Section 4.0, **Supplemental Investigation Approach**, summarizes the Phase 2 ESA findings to date and presents the planned sample collection/analysis approach for the supplemental field activities at the Facility.

Section 5.0, **Sampling and Analysis Procedures**, describes the procedures to be implemented for the field sampling and laboratory analysis activities; references the quality assurance and quality control measures to be implemented for all data collection activities; and references the health and safety procedures to be utilized for all field investigation activities.

Section 6.0, **Development of Remedial Action Objectives**, presents the preliminary remediation objectives (PROs) for the Facility and discusses general response actions that have been developed to meet the objectives.

Section 7.0, **Identification and Screening of Remedial Technologies**, presents the remedial action technologies identified and the results of the preliminary technology screening.

Section 8.0, **Development and Detailed Analysis of Remedial Action Alternatives**, identifies the remedial action alternatives that have been developed, discusses the detailed analysis procedure, describes and evaluates each of the remedial action alternatives, and then compares all of the remedial action alternatives.

Section 9.0, **Selection of Recommended Alternative**, provides a summary of the recommended alternative with respect to the various evaluation standards.

Section 10.0, **References**, provides a list of references that were used in the development of this RAP document.

2.0 Description of Current Conditions

This section of the RAP document presents background information pertaining to the environmental setting and existing conditions at the Facility. The information below represents an overview of the results provided in the Boeing Phase 2 ESA Report (Volume 2) dated November 16, 2000.

2.1 Facility Location

The Facility is located at the northeast corner of the intersection of Lindbergh Boulevard and Banshee Road. It is bounded on the west by Lindbergh Boulevard, on the south by Banshee Road, and on the east by Coldwater Creek. With the exception of Building 220, McDonnell Boulevard bounds the northern portion of the Facility. Building 220 is located immediately north of McDonnell Boulevard. The Facility is located in the northwest quarter of Section 5, Township 46 North, Range 6 East, St. Louis County, Missouri.

2.2 Environmental Setting

A preliminary evaluation of the environmental setting at the Facility was initially prepared to better understand the framework for migration of any potential constituent releases and the potential effects on human health and the environment. This information is presented below.

2.2.1 General Setting

The Facility is surrounded by other Boeing operations on the south, commercial and industrial facilities on the west and north, and Coldwater Creek on the east. According to information obtained from the MDNR, Division of Geology and Land Survey, no wells are located within a 1½-mile radius of the Facility [RCRA Facility Assessment (RFA), 1995]. Surface water from the Facility drains toward Coldwater Creek which flows along the Facility's eastern boundary.

2.2.2 Geology

Soil boring data indicate the presence of four general soil stratigraphic units overlying the bedrock surface at the Facility. These four general units are defined in descending order as the (1) Fill Unit, (2) Silty Clay Unit, (3) Silt Unit, and (4) Clay Unit.

Geotechnical lab results indicate that vertical hydraulic conductivity decreases with depth. Values ranged from 3.1×10^{-4} cm/sec for a sample collected from 10-12 ft bls (Silty Clay Unit) to 1.2×10^{-8} cm/sec for a sample collected from 75-76 ft bls (Clay Unit).

Fill Unit

Soil boring data indicate that a heterogeneous Fill Unit overlies the native materials at some portions of the Facility. Fill generally consisted of a mixture of materials either excavated at the site or brought in as clean fill during Facility construction/modification activities. Unit thickness varied between the buildings, but was typically less than 3 feet in thickness. For the majority of the Facility evaluated in this Phase 2 ESA, buildings and concrete/asphalt pavement overlie the Fill Unit.

Silty Clay Unit

Soil boring data indicate the presence of a Silty Clay Unit beneath the surface or the previously defined Fill Unit. These native materials generally consisted of olive-gray to reddish-brown, soft to stiff, silty clay. The silty clay often contained iron oxidation discoloration and numerous open, discontinuous channels, which are likely vertical root scars. Unit thickness generally ranged from 6-12 feet. Shallow groundwater in the Silty Clay Unit was typically perched on the underlying units, although depths varied dramatically (e.g. 3-5 ft bls at Building 22, 9-10 ft bls at East Parking Lot, 6-12 ft bls inside of Building 27, and not encountered from 0-16 ft bls for one location inside of Building 27).

Silt Unit

Soil boring data indicate the presence of a Silt Unit underlying the Silty Clay Unit. The native materials appear to be Lacustrine (lake-formed) in origin and are very thinly bedded with abundant organic debris (wood fragments and twigs). The silt is dark reddish-brown, medium-stiff, and slightly moist. Unit thickness was generally between 1-3 feet. Due to the low moisture content of the silt and the presence of perched groundwater in the overlying Silty Clay Unit, the Silt Unit and underlying Clay Unit appear to act as an aquitard.

Clay Unit

Soil boring data from the deep groundwater monitoring wells indicate the presence of a Clay Unit underlying the Silt Unit. These native materials generally consisted of light to dark gray, stiff to very stiff, plastic clay. This unit was generally encountered between 15-20 ft bls and extended to a depth of approximately 80 ft bls. Within 2-4 ft above the top of the bedrock surface, the Clay Unit graded into a silty clay to clayey silt with coarse gravel intermixed in the clay matrix.

Based on interpretations from Phase 2 ESA boring results, previous investigations, and regional geological information, the Silt Unit and the Clay Unit are expected to be relatively uniform and continuous beneath the Facility and immediately surrounding area. As such, the units serve as an aquitard beneath the Facility, effectively limiting any vertical migration of groundwater.

2.2.3 Hydrogeology

As previously indicated, shallow groundwater was typically encountered in the Silty Clay Unit. However, this material has little potential to produce water as exemplified by the difficulties in acquiring sufficient sample volumes from temporary piezometers at Building Nos. 21, 27, and 29.

Shallow groundwater was encountered at a range of depths for the various borings as summarized below for representative locations:

- Building 220 – 2-6 ft bls;
- Building 22 – 3-5 ft bls;
- Recycling and Haz Waste Areas – 5-6 ft bls;
- Building 220 interior – 9 ft bls;
- East Parking Lot – 9-10 ft bls;
- Building 27 interior – 6-12 ft bls;
- Building 29 interior – 13 ft bls; and
- Boring B27I3 – Not encountered from 0-16 ft bls.

As stated in the previous section, the Facility is underlain by low permeability clay and silt. Because of the low permeability of these units, groundwater quantities are generally low. The shallow groundwater table may be modified locally at the Facility due to the presence of buildings or parking lots. Groundwater elevation surface maps indicate general flow of shallow groundwater toward the east and Coldwater Creek. Given the low permeability and thickness of the unconsolidated deposits underlying the Facility, a direct connection to deeper bedrock aquifers is not expected.

Water was encountered in the deep wells near the top of bedrock in a clayey silt to silty clay that contained coarse gravel. Water levels recorded in the deep wells installed in the Clay Unit at approximately 70-80 ft bls indicate that the deep water-bearing unit is under artesian conditions. Artesian conditions exist when the water level in a well rises above the top of the unit and are indicative of a confined water-bearing unit.

The uppermost bedrock encountered in the area of the Facility is the undifferentiated Pleasanton, Marmaton, and Cherokee Groups of Pennsylvanian age. Shales, siltstones, sandstones, coal beds, and thin limestone beds are the dominant lithology of these three groups. Regionally, the Pennsylvanian-age groups have a total thickness ranging from 10-300 feet.

Underlying the Pennsylvanian strata is Mississippian-age limestone. The Ste. Genevieve Formation (0-160 feet thick), St. Louis Limestone (0-180 feet thick), Salem Formation (0 to 180 feet thick), and Warsaw Formation (0-110 feet thick) are all limestone and compose the upper portion of the Mississippian-age bedrock.

2.2.4 Surface Water Hydrogeology

General surface water drainage at the Facility is by overland flow to storm sewer intakes located across the Facility or to open drainage ditches that drain to storm sewers. The storm sewers discharge into Coldwater Creek at several locations. Coldwater Creek flows northeast within an underground culvert from the southwest side of Lambert-St. Louis International Airport, across the central portion of the airport, and the easternmost part of Tract I South. The creek flows within an open culvert north of Banshee Road along the eastern boundary of Tract I North. Coldwater Creek then flows northeast within this open culvert for several miles until it rejoins its original channel. The creek eventually discharges into the Missouri River. At its closest point, the Missouri River is approximately 3 miles to the northwest of the Facility.

Presently, approximately 90-95 percent of the surface area is covered with buildings, paved streets, paved parking lots, tank areas, and docks. Several of the aboveground structures associated with discontinued processes have been demolished, although concrete at or below grade remains. An extensive network of utilities including potable and service water lines, storm sewers, sanitary sewers, and other utilities (typical of an industrial facility) is located underground.

2.3 Investigation Activities

Initial Phase 2 ESA field activities were conducted in July-August 2000 (Phase 2A) and supplemental Phase 2 ESA activities were conducted in September-October 2000 (Phase 2B) to evaluate potential environmental impacts at the Facility. These activities included: soil boring installations, soil sampling and analyses, temporary piezometer/monitoring well completion, groundwater monitoring and analyses (shallow and deep water-bearing units), wipe sampling and analyses. Most of the Phase 2 field activities were completed on a site-specific basis for both soil, groundwater, and surface evaluation purposes. A groundwater monitoring well network was also completed to assess groundwater conditions on a Facility-wide basis.

The following general chronology of field activities was completed to fulfill the Phase 2A scope of work as outlined in the Phase 2 ESA Work Plan:

1) Installation of 40 investigative soil borings to assess geological and hydrogeological conditions beneath the Facility;
2) Installation of 36 temporary piezometers to assess hydrogeological conditions beneath the Facility;
3) Installation of 8 shallow groundwater monitoring wells to assess hydrogeological conditions beneath the Facility;

4) Sampling of subsurface soils utilizing continuous collection methods;
5) Collection of subsurface soil samples for field screening and laboratory analyses;
6) Collection of groundwater samples for field screening and laboratory analyses;
7) Collection of wipe samples for laboratory analyses; and
8) Monitoring of groundwater surface.

The following general chronology of supplemental field activities was completed to fulfill the Phase 2B scope of work as outlined in the Workplan Addendum for the Phase 2 ESA:

1) Installation of 19 investigative soil borings to assess geological and hydrogeological conditions beneath the Facility;
2) Installation of 3 piezometers to assess hydrogeological conditions beneath the Facility;
3) Installation of 15 temporary piezometers to assess hydrogeological conditions beneath the Facility;
4) Installation of 9 groundwater monitoring wells (4 shallow monitoring wells and 5 deep monitoring wells) to assess hydrogeological conditions beneath the Facility;
5) Sampling of subsurface soils utilizing continuous collection methods;
6) Collection of subsurface soil samples for field screening and laboratory analyses;
7) Collection of groundwater samples for field screening and laboratory analyses; and
8) Monitoring of groundwater surface.

2.4 Investigation Findings

Phase 2A/2B ESA analytical results for the groundwater samples collected from specific portions of the Facility indicate the presence of constituent impacts to the shallow water-bearing unit. VOCs were consistently detected in groundwater samples beneath/adjacent to most portions of Building 27 and the only sample collected beneath Building 220. Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE, vinyl chloride, 1,1-DCE, and 1,1-DCA). Elevated diesel petroleum hydrocarbons were also detected in one isolated groundwater sample to the immediate north of Building 220. No constituent impacts were detected in the deep water-bearing unit.

Phase 2A/2B ESA analytical results for soil samples collected from the Facility indicate the presence of isolated constituent impacts to subsurface soils. Elevated VOCs were detected in soil samples beneath/adjacent to several portions of Building 27 and the only sampling location beneath Building 220. Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE, vinyl chloride, 1,1-DCE, and 1,1-DCA). PCBs were detected at an isolated location to the west-northwest of Building 27. Elevated diesel petroleum hydrocarbons were detected in soil samples along the southeast corner of Building 27. No herbicide or pesticide impacts were detected in any of the soil samples collected adjacent to the railroad tracks along the north side of Banshee Road or to the west of Building 27.

Phase 2A/2B analytical results largely defined the nature and extent of constituent impacts to subsurface soils and the shallow water-bearing unit at the Facility. Approximate delineation of constituent impacts to subsurface soils and the shallow water-bearing unit are displayed in Figures 2-1 and 2-2, respectively. However, supplemental Phase 2C field investigation tasks are recommended at isolated areas to further delineate any potentially impacted subsurface soils or shallow groundwater. These proposed Phase 2C field investigation tasks are described in Section 4.0.

2.5 Source for Detailed Background Information

As previously described, the content of this section was derived from the Boeing Phase 2 ESA Report dated November 16, 2000 which summarizes the investigation activities and results to date. The Phase 2 ESA Report should be reviewed to acquire additional background information regarding the Facility investigation.

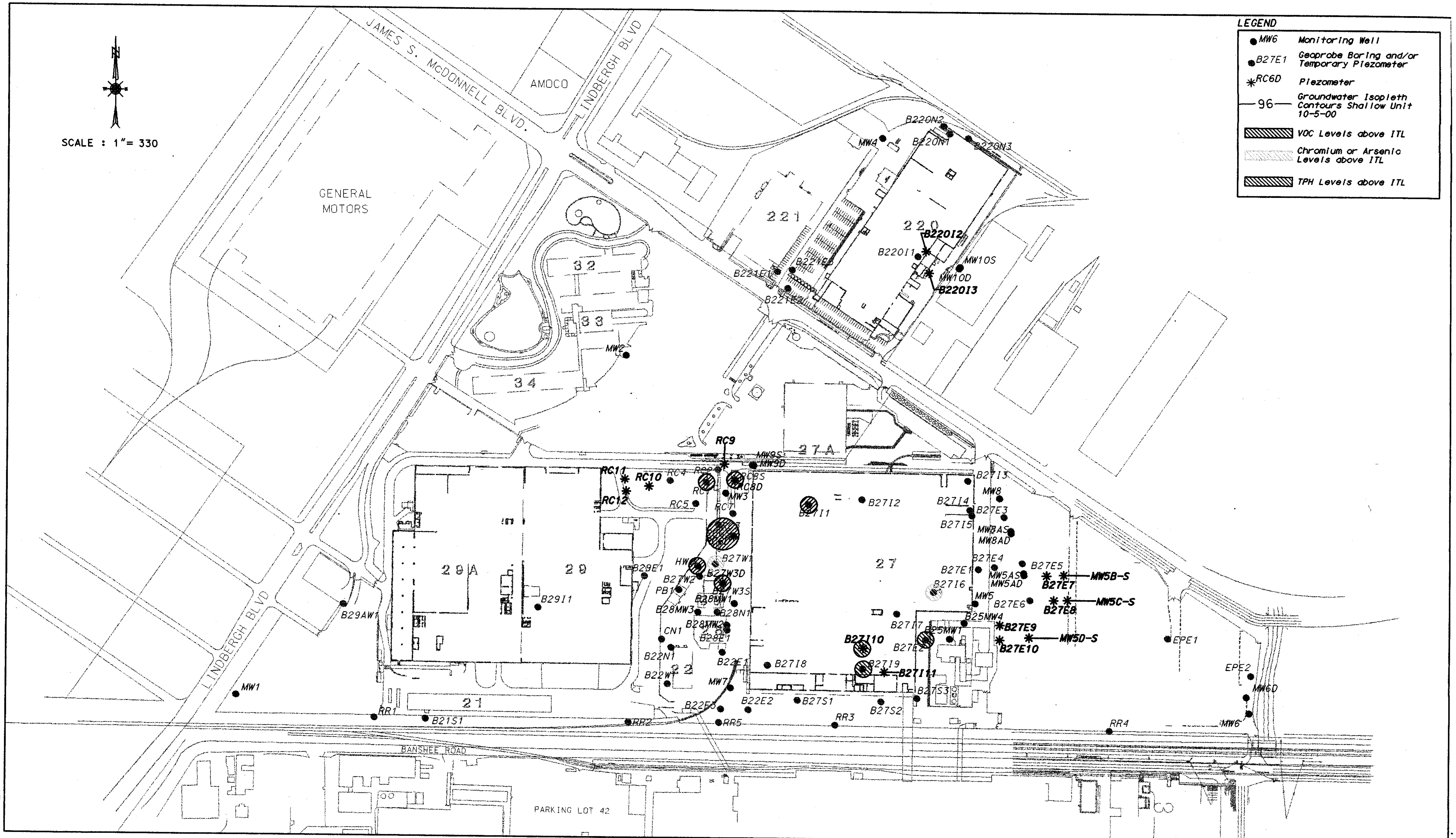

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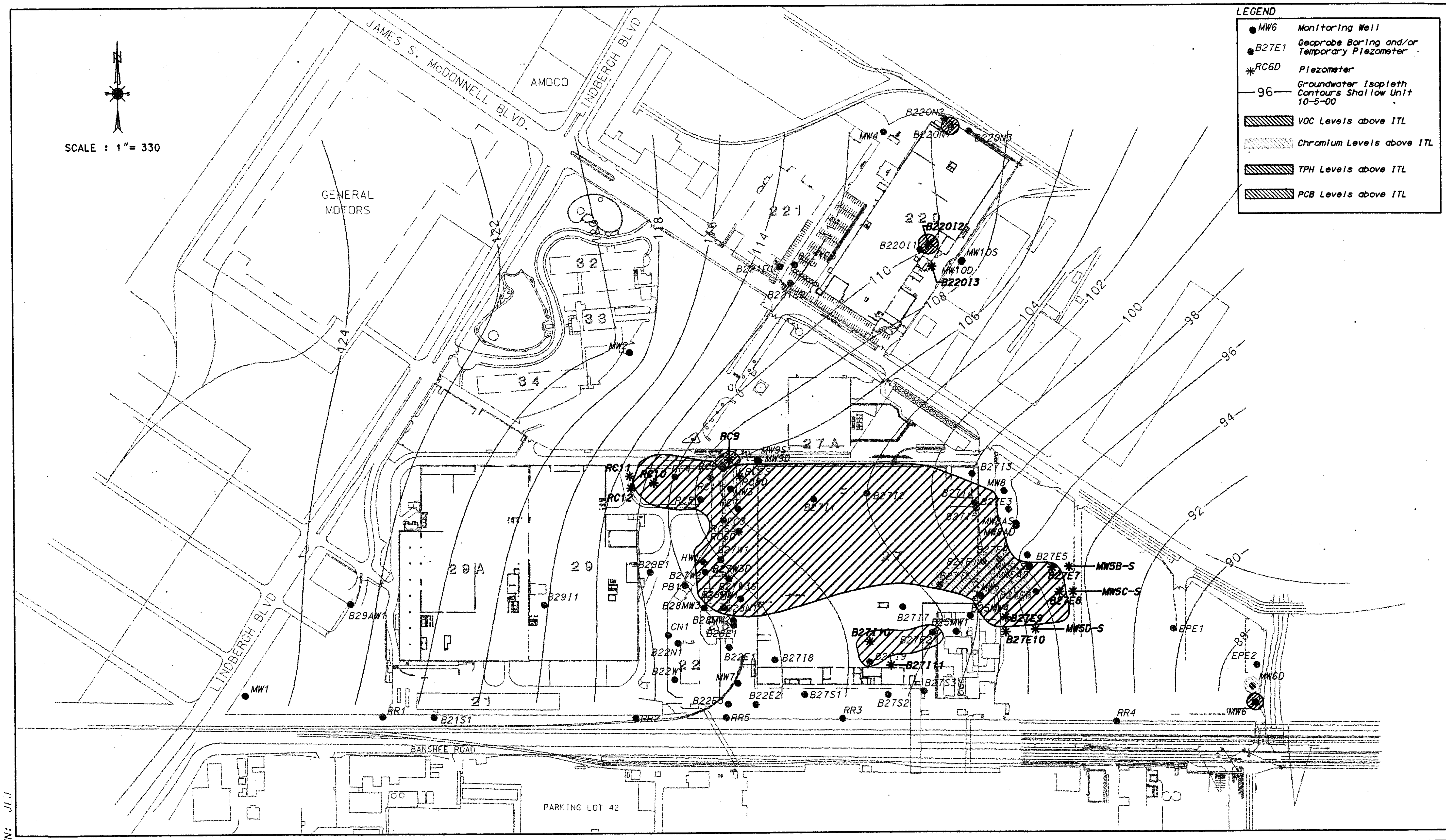
Figure 2-1
Approximate Constituent Delineation in Subsurface Soils

Harding ESE
A MACTEC Company
3199 Riverport Tech Center Drive
St. Louis, MO 63043
314-209-5900

510098-0300 DRAWN: JLJ



THE BOEING COMPANY

Figure 2-2
Approximate Constituent Delineation in Shallow Water-Bearing Unit

Harding ESE
A MACTEC Company
3199 Riverport Tech Center Drive
St. Louis, MO 63043
314-209-5900

510098-0300 DRAWN: JLJ

3.0 Project Management

The overall project management approach for the Boeing RAP is detailed in the previous Phase 2 ESA Workplan prepared by Golder Associates in May 2000. Project management modifications are summarized below.

3.1 Schedule

Based on the expedited timeframes necessitated by the potential property transaction, the supplemental field investigation and drilling tasks described in this RAP are scheduled to begin on Monday, October 30, 2000. Initiation of the design tasks associated with the proposed remedial actions are scheduled to begin on December 4, 2000. Duration of MDNR review processes, which control the start date of mobilization and field activities, has been estimated based upon conversations between MDNR and Boeing personnel.

3.2 Project Organization and Personnel

Boeing has contracted the environmental consulting firm of Harding ESE, Inc. (formerly Environmental Science & Engineering, Inc. [ESE]) to support Boeing in completing this project. An organizational structure for the project has been developed to promote technical excellence, promote quality data collection and deliverables, enable a free flow of communications among project team members, and ensure adherence to schedule.

The efforts to be conducted during the Phase 2 ESA have been divided into several different tasks to facilitate the most efficient use of qualified technical resources and ensure adequate oversight. All task managers report directly to the Harding ESE Project Manager who in turn reports to the Boeing Project Manager. Subcontractor activities are under the direct supervision and control of the Harding ESE Project Manager and Field Implementation Manager.

Supervisory personnel and their assigned responsibilities are described below:

<u>Boeing Project Manager</u>

Mr. Bryan Kury, Manager of Environmental and Hazardous Material Services, will serve as the Boeing Project Manager. He is responsible for implementing the project on behalf of Boeing and has the authority to commit the resources necessary to meet project objectives and requirements. The Boeing Project Manager's primary function is to ensure that legal, financial, technical, and scheduling objectives are achieved successfully. The Boeing Project Manager will serve as the primary interface with the MDNR Project Manager, Mr. Richard Nussbaum, and will provide the primary point of contact and control for matters concerning the project.

The Boeing Project Manager's responsibilities include:

- Coordination of Boeing review for all submittals and deliverables;
- Final approval of all submittals and deliverables;
- Coordination with Harding ESE and regulatory agency personnel;
- Coordination with the Harding ESE Project Manager to correct any problems which may arise during the course of the Phase 2 ESA; and
- Assuring compliance with all legal and Boeing contractual requirements.

As a Senior Manager for Boeing, Mr. Kury has considerable experience negotiating permits and overseeing RCRA Corrective Action, permitting, and closure activities on behalf of the Facility.

<u>Harding ESE Project Manager</u>

Mr. Doug Marian will serve as the Harding ESE Project Manager for the Boeing Phase 2 ESA program. Mr. Marian maintains overall responsibility for ensuring that the project meets MDNR, USEPA, and Boeing objectives and quality standards. Reporting directly to the Boeing Project Manager, his primary functions include strategy development, technical quality control, ensuring appropriate Boeing communications with MDNR, project oversight, and daily management of all Phase 2 ESA activities. All Harding ESE task managers and subcontractors report to Mr. Marian. Specific responsibilities of the Harding ESE Project Manager include:

- Preparation and oversight of technical and administrative workplans, including approval of sampling/monitoring site locations, analytical parameters, field procedures, schedules, and manpower allocations;
- Preparation of quarterly progress reports, including schedule updates;
- Management of all funds for labor and materials procurement;
- Direct communication with the Boeing Project Manager;
- Technical review of all project deliverables;
- Assurance of cost-effective implementation for all project work;
- Verification of compliance with all project-related Boeing and legal requirements applicable to the Harding ESE project team;
- Maintaining site team integrity throughout the period of performance; and
- Coordination of site teams and support personnel to ensure consistency of performance and adherence to project schedule.

As a Senior Engineer with Harding ESE, Mr. Marian has 15 years of experience in the hazardous waste field including participation in 20 RCRA/CERCLA projects nationwide. In addition to the

Boeing project, he serves as Project Manager/Engineer on three other site investigation projects currently being conducted by Harding ESE.

Project Quality Assurance Manager

Ms. Lana Smith is the designated Harding ESE Environmental Quality Assurance/Data Validation Manager for the Boeing Phase 2 ESA. As the Project Quality Assurance Manager, Ms. Smith's primary responsibilities are to monitor field data collection procedures and to ensure appropriate analysis/review by qualified technical staff. Specific responsibilities of the Consultant Project Quality Assurance Manager include:

- Ensuring that QA procedures, as identified in the QAPP, are followed:
- Verifying that adequate QA documentation is provided for analytical, field programs, and engineering calculations;
- Determining that all QA problems are resolved in an expeditious manner and brought to the attention of the Harding ESE Project Manager;
- Coordinating and ensuring that all applicable QA procedures are followed by any subcontractors; and
- Ensuring that observations, conclusions, and recommendations have been reviewed by qualified and appropriate technical personnel.

With more than 13 years of experience in the environmental field, Ms. Smith has specialized expertise in the development of QAPPs and data validation. Currently, she is providing similar services for a hazardous waste site investigation study for a coal gasification facility in USEPA Region 5.

Field Implementation Manager

The Field Implementation Manager, Mr. Dennis Brinkley, P.E., R.G., is responsible for the technical work performed during the field investigation component of the Phase 2 ESA. His duties include:

- Development/implementation of field-related work plans, assurance of schedule compliance, and adherence to management-developed study requirements;
- Coordination of field activities between Harding ESE personnel and subcontractors;
- Review of all field sampling data for compliance with the QAPP and for technical accuracy;
- Review and interpretation of all geologic data;
- Confirming that adequate field quality control documentation is provided;
- Ensuring that all field problems are resolved in an expeditious manner and brought to the attention of the Harding ESE Project Manager; and
- Ensuring compliance with the HASP and other applicable safety precautions.

A geological engineer with 13 years of experience in the environmental field, Mr. Brinkley is extremely familiar with hydrogeologic conditions in the greater St. Louis area. Currently, he serves as Project Manager for two ongoing hazardous waste site investigations in USEPA Region 7.

Phase 2 ESA Report Manager

The Phase 2 ESA Report Manager, Mr. Doug Marian, will be responsible for evaluation and presentation of data, as well as production of the draft and final Phase 2 ESA reports. His specific duties include:

- Review and interpretation of all validated analytical data;
- Summary of contaminant data in both tabular and graphic forms; and
- Production of draft and final Phase 2 ESA Reports.

Risk Assessment Manager

The Risk Assessment Manager, Mr. Jim Kountzman, will be responsible for identification of potential exposure pathways, analysis of data comparison to risk-based standards, and the completion of risk assessments, as necessary. His specific duties include:

- Development of site-specific investigation thresholds, as necessary, against which the Phase 2 ESA data will be compared;
- Identification of complete exposure pathways which will be addressed, as necessary, during future risk assessment activities; and
- Completion of human health risk assessments as determined to be necessary by the results of the Phase 2 ESA findings.

A senior toxicologist with more than 19 years of professional experience, Mr. Kountzman has performed both human health and ecological risk assessments at RCRA Corrective Action, CERCLA, and state voluntary program sites within USEPA Regions 7, 5, and 4. As such, he is quite familiar with the specific policy and guidance required in each Region.

Health and Safety Manager

Ms. Lana Smith is the designated Harding ESE Health and Safety Manager for the Boeing Phase 2 ESA. As the Health and Safety Manager, Ms. Smith's primary responsibilities are to identify health and safety issues of concern prior to field mobilization, assist the Project Manager in preparing safety plans for site activities, and train project personnel in appropriate safety practices.

Her specific duties, per the Boeing Site-Specific Health and Safety Plan (HASP) are listed below:

- Maintaining and implementing the site-specific HASP;
- Approving any changes in the HASP due to modifications of procedures or newly-proposed site activities related to the Phase 2 ESA Workplan;

- Providing health and safety issues coordination between the Harding ESE Project Manager, the Boeing Project Manager, and other contractors on the project;
- Resolving outstanding safety issues which arise during the conduct of site work;
- Assigning health and safety-related duties to qualified field team individuals;
- Ensuring that personnel maintain acceptable current medical examinations prior to beginning on-site work;
- Ensuring the acceptability of health and safety training; and
- Issuing authorization, in cooperation with the project manager, to proceed with work after a **STOP WORK** action has been issued on-site.

Ms. Smith currently serves as the Harding ESE Regional Health and Safety Representative (RHSR) and, as such, is trained and qualified in the development/implementation of HASPs at hazardous waste sites.

Supplemental Technical Staff

Additionally required technical support will be drawn from Harding ESE's pool of local resources. Supplemental technical staff will be utilized to gather/analyze data and to prepare various task reports/ supporting materials. All of the designated technical team members are experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work. Specific individual responsibilities will include:

- Provision of day-to-day technical assistance in specific areas of expertise;
- Coordination and management of field personnel including subcontractors;
- Application of quality control measures to technical data provided by the field staff, including field measurement data;
- Maintaining field logs and transferring data for permanent storage; and
- Participating in preparation of the final report.

Subcontractors

Harding ESE will utilize TEG Mid-America, Inc. (St. Louis, Missouri) for on-site laboratory services. Severn Trent Laboratories (Earth City, Missouri) and American Technical & Analytical Services, Inc. [ATAS] will be used to complete the required off-site laboratory analyses. Each laboratory possesses the capability to perform the required analytical methods and the associated QA/QC back-up data.

Harding ESE will utilize the services of Roberts Environmental Drilling, Inc. (Millstadt, IL) to complete the required soil boring, monitoring well, and temporary piezometer installation efforts. Roberts Drilling retains experienced, licensed personnel who maintain the required OSHA health and safety training certifications. Harding ESE will provide overall project management, coordination, and quality control of subcontractor activities in accordance with the RAP objectives.

4.0 Supplemental Investigation Approach

This section of the RAP describes the approach that will be utilized to conduct supplemental investigations at the Facility (Phase 2C ESA). Results from the initial Phase 2A and 2B investigation activities are summarized at the beginning of each sub-section to establish the basis for the Phase 2C investigation efforts. Recommended approaches for sampling and analysis are then provided along with supporting rationale to characterize the nature and extent of any potential hazardous constituent/ waste releases to soil or groundwater at the Facility.

4.1 Overview of Sampling Approach

A biased sampling approach will be used to locate the Phase 2C ESA sampling locations. The approximate locations, number of samples, and analyses have been determined using the following criteria:

- Phase 2A soil boring and analytical results acquired in July-August, 2000;
- Phase 2B soil boring and analytical results acquired in September, 2000;
- soil boring and analytical results from previous investigations at the Facility;
- facility/property layout;
- hazardous constituents or wastes managed;
- field conditions (e.g. staining, cracks, obstructions); and
- historical operations or procedures performed at the specific building/site.

A discussion of the specific investigative approach for each area is provided in the following subsections. The proposed sampling locations are approximate and subject to slight revision at the time of sampling, based on field observations and encountered conditions. Table 3-1 presents a summary of the supplemental investigation parameters for each area including: number of borings, number of groundwater monitoring points, number of samples, target constituents, analytical methods, sample selection criteria, sample collection method, and projected minimum boring depth.

Subsurface soil and groundwater sampling methods will be conducted to further evaluate environmental conditions at the Facility. In the event that the selected sampling method proves unsuitable at a specific location due to access restrictions, subsurface restrictions, or unsuitable soils, an alternate sampling method may be employed. Any alternate sampling methods must be capable of collecting representative samples in a manner which is consistent with the objectives of the Phase 2 ESA. Due to the presence of buried utilities in the area, actual sampling locations will be determined through discussions with Boeing facilities personnel and confirmed in the field prior to sampling.

Approximate locations for the proposed soil borings, monitoring wells, and temporary piezometers are displayed in Figure 3-1.

4.2 Supplemental Groundwater Investigation Tasks

Phase 2A/2B ESA analytical results for the groundwater samples collected from specific portions of the Facility indicate the presence of constituent impacts to the shallow water-bearing unit. VOCs were consistently detected in groundwater samples beneath/adjacent to most portions of Building 27 and the only sample collected beneath Building 220. Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE, vinyl chloride, 1,1-DCE, and 1,1-DCA). No constituent impacts were detected in the deep water-bearing unit.

Phase 2B results largely defined the nature and extent of constituent impacts to the shallow water-bearing unit. However, supplemental field investigation tasks are recommended at isolated areas (east southeast of Building 27; southeast corner of Building 27; portions of the Recycling Area; and along east side of Building 220) to further delineate any potentially impacted groundwater in the shallow water-bearing unit.

4.2.1 Supplemental Groundwater Evaluation at Building 27

Phase 2A/2B ESA analytical results for the groundwater samples collected from the Facility indicate the presence of constituent impacts at an area beneath and surrounding Building 27. VOCs were consistently detected to the west of Building 27 (hydraulically upgradient), beneath most portions of Building 27, and to the east of Building 27 (hydraulically downgradient). Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE, vinyl chloride, 1,1-DCE, and 1,1-DCA). Supplemental Phase 2C ESA field investigation tasks are recommended to further delineate impacted groundwater in the shallow water-bearing unit.

4.2.1.1 Investigation of Downgradient Locations

Several VOC and metal (primarily chromium) constituents of concern exceed groundwater ITLs to the east (downgradient) of Building 27. Phase 2B analytical results largely defined the horizontal and vertical extent of these constituent impacts. However, supplemental Phase 2C investigation tasks are recommended to evaluate groundwater conditions in this area. These supplemental tasks are summarized below.

Evaluation of VOC Impacts to the East of Building 27

Additional Geoprobe borings (B27E7, etc.) will be located to the east of Building 27 to help delineate the horizontal extent of VOC impacts to groundwater. Boeing's objective is to establish an additional "clean" shallow groundwater monitoring point that will delineate the extent of any downgradient impacts. These locations will also serve to further delineate the horizontal extent of potential VOC impacts to soil to the east of Building 27.

Soil samples will be collected at selected intervals from each of the soil borings. Based on an anticipated groundwater elevation of 8-10 ft bls, each soil boring will be completed to an approximate depth of 20 ft bls.

With the objective of identifying "clean" soil and groundwater verification samples, Boeing will collect and submit representative soil samples from different depths and one groundwater sample (if encountered) for on-site lab analysis of VOCs. Samples will be screened for on-site analysis utilizing appropriate field instrumentation including a photoionization detector (PID). The Harding ESE field geologist will also retain authority to analyze samples on the basis of visual/olfactory means.

If detectable PID readings are encountered for any of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for on-site analysis. Furthermore, if evidence of TCE/VOC impacts is encountered at a boring location, an additional set of borings will be advanced at a location which is approximately 50 ft further east of Building 27 (hydraulically downgradient). This "step-out" process will be utilized to accurately delineate the horizontal extent of any VOC impacts and optimize placement of the subsequent monitoring well. If unexpected field conditions are encountered, the Harding ESE field geologist and Boeing will discuss any recommended changes in sampling approach.

One shallow groundwater monitoring well (MW5B-S) will be completed immediately adjacent to the "clean" Geoprobe boring. Following development and purging of this well, groundwater samples will subsequently be collected from this monitoring well as part of the Phase 2C groundwater monitoring program. This monitoring program is described in Section 3.2.3.

Evaluation of Chromium Impacts to the East of Building 27

Additional Geoprobe borings (B27E8, B27E9, B27E10, etc.[consecutively numbered following completion of the VOC evaluation previously described]) will be located to the east of Building 27 to help delineate the horizontal extent of chromium impacts to groundwater. Boeing's objective is to establish 2 additional "clean" shallow groundwater monitoring points that will delineate the extent of any downgradient impacts. These locations will also serve to further delineate the horizontal and vertical extent of any chromium impacts to soil to the east of Building 27.

Soil samples will be collected at selected intervals from each of the soil borings. Based on an anticipated groundwater elevation of 8-10 ft bls, each soil boring will be completed to an approximate depth of approximately 20 ft bls.

With the objective of identifying "clean" soil and groundwater verification samples, Boeing will collect and submit representative soil samples from 2 different depth intervals (approximately 4-8 ft bls and 16-20 ft bls) for off-site lab analysis. The Harding ESE field geologist will retain the authority to select samples on the basis of visual discoloration.

If detectable PID readings are encountered for any of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest reading and submitting it for on-site VOC analysis. Furthermore, if evidence of elevated chromium or TCE/VOC impacts is encountered at a boring location, an additional set of borings will be advanced at a location which is approximately 50 ft further east of Building 27 (hydraulically downgradient). This "step-out" process will be utilized to accurately delineate the horizontal extent of any metals and/or VOC impacts, and optimize placement of subsequent monitoring wells. If unexpected field conditions are encountered, the Harding ESE field geologist and Boeing will discuss any recommended changes in sampling approach.

Two shallow groundwater monitoring wells (MW5C-S and MW5D-S) will be completed immediately adjacent to the "clean" Geoprobe borings. Following development and purging of these wells, groundwater samples will subsequently be collected from each of the wells as part of the Phase 2C groundwater monitoring program. This monitoring program is described in Section 3.2.3.

In addition to the above-referenced sampling activities, Boeing will perform a video inspection of the industrial sewer lines in the immediate vicinity of the Plating Shop operations near Boring B27E1. Results from the video inspection will be used to verify the integrity of these sewer lines.

4.2.1.2 Investigation of Recycling Area and Hazardous Waste Area

Several VOCs and metal constituents of concern exceed groundwater ITLs within the area to the west of Building 27 (Recycling and Hazardous Waste Areas). Phase 2B analytical results largely defined the horizontal and vertical extent of these constituent impacts in the shallow water-bearing unit. However, supplemental Phase 2C investigation tasks are recommended to further evaluate groundwater conditions in the Recycling Area. These supplemental tasks are summarized below.

Approximately 2 additional soil borings (RC9, RC10) will be located within the potential source area west of Building 27 to help delineate the horizontal extent of VOC impacts to groundwater and soil in this area.

Soil samples will be collected continuously from each of the soil borings in this area. Based on an anticipated groundwater elevation of 5-10 ft bls, these soil borings will each be completed to an approximate depth of 16 ft bls.

With the objective of delineating the horizontal and vertical extent of any soil and/or groundwater impacts in this area, representative soil samples from different depths and one groundwater sample (if encountered) will be collected/screened for on-site lab analysis. If detectable PID readings are encountered for any of the borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for on-site analysis of VOCs. The Harding ESE field geologist will also retain authority to analyze samples on the basis of visual/olfactory means. Additional soil and groundwater samples (unfiltered and filtered) will be collected from RC9 to evaluate the potential presence of PCBs.

Additional borings may be advanced in this area depending on the detected VOC concentrations. This process will be utilized to reasonably delineate the horizontal extent of any VOC impacts and optimize placement of any subsequent sampling locations. If unexpected field conditions are encountered, the Harding ESE field geologist and Boeing will discuss any recommended changes in sampling approach.

Specialized Geoprobe sampling equipment will be used to evaluate soil and groundwater conditions at RC10. A Dual Tube sampler will be used to eliminate potential cross-contamination between the water-bearing units. Two sets of probe rods are used to collect continuous soil samples as follows:

1) The outer set of 2.125-inch OD rods is initially driven into the ground as a protective casing. These rods provide a sealed hole that eliminates the potential of any side slough and enables the collection of soil samples across a perched water table.

2) The second smaller set of 1.0-inch OD rods are then placed inside of the outer casing. The smaller rods hold a sample liner in place as the outer casing is driven one sampling interval.

3) The smaller rods are then retracted to collect the soil sample from the filled liner.

Soil boring RC10 will be completed to an approximate depth of 16 ft bls to evaluate conditions beneath the shallow water-bearing unit. Groundwater samples will be collected from each location and tested for oxidation/reduction potential and dissolved oxygen using appropriate field screening instrumentation. This field data will be useful in assessing the biodegradability of VOCs in groundwater at this area.

To prevent cross-contamination during abandonment, each Dual Tube boring will be grouted from the bottom up while retracting the outer casing.

4.2.1.3 Investigation of Southeast Interior Corner of Building 27

Phase 2A ESA analytical results indicate that TPH levels (extractable fraction) for one sampling location in the southeast corner of Building 27 (B27I9) exceed soil and groundwater ITLs. As a result, limited Phase 2C ESA field investigation tasks are recommended to further evaluate the nature and extent of impacted soil/groundwater beneath this location. These supplemental tasks are summarized below.

Additional Geoprobe borings (B27I10, B27I11) will be located within the southeast corner of Building 27 to help delineate the horizontal/vertical extent of petroleum hydrocarbon impacts to subsurface soil and/or groundwater.

Soil samples will be collected at selected intervals from each of the soil borings. Based on an anticipated groundwater elevation of 6-8 ft bls, each soil boring will be completed to an approximate depth of 20 ft bls.

With the objective of delineating the horizontal and vertical extent of any soil and/or groundwater impacts in this area, representative soil samples from different depths and one groundwater sample (if encountered) will be collected/screened from each boring for on-site lab analysis. Samples will be screened for on-site analysis utilizing appropriate field instrumentation including a PID. The Harding ESE field geologist will also retain authority to analyze samples on the basis of visual/olfactory means.

If detectable PID readings <u>are</u> encountered for any of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for on-site VOC analysis. Furthermore, if evidence of TPH impacts is encountered at a boring location, an additional boring will be advanced at a location that is further east (hydraulically downgradient) of the initial location. This "step-out" process will be utilized to accurately delineate the horizontal extent of any TPH impacts. If unexpected field conditions are encountered, the Harding ESE field geologist and Boeing will discuss any recommended changes in sampling approach. One groundwater sample (if encountered) will be collected from each boring location using a temporary piezometer for off-site analysis of TPH.

4.2.2 Supplemental Groundwater Evaluation at Building 220

Phase 2A ESA analytical results for the groundwater sample from B220I1 indicate the presence of VOC impacts beneath Building 220. Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE and 1,1-DCE). TCE exceeds the groundwater ITL at this location. As a result, supplemental Phase 2B investigation tasks were completed to further evaluate the nature and extent of impacted groundwater in the vicinity of Building 220.

Phase 2B analytical results largely defined the horizontal and vertical extent of these constituent impacts. Groundwater concentrations did not exceed ITLs for either of the shallow or deep groundwater monitoring wells that were installed. However, supplemental Phase 2C investigation tasks are recommended to more precisely define the horizontal extent of potentially impacted shallow groundwater beneath Building 220. These supplemental tasks are summarized below.

<u>Evaluation of VOC Impacts Beneath Building 220</u>

Two additional Geoprobe borings (B220I2, B220I3) will be located beneath and/or immediately east of Building 220 to help delineate the horizontal extent of VOC impacts to shallow groundwater. Boeing's objective is to establish additional "clean" shallow groundwater monitoring points that will further delineate the extent of any downgradient impacts.

Soil samples will be collected at selected intervals from each of the soil borings. Based on an anticipated groundwater elevation of 6-8 ft bls, each soil boring will be completed to an approximate depth of 20 ft bls.

With the objective of delineating the horizontal and vertical extent of any soil and/or groundwater impacts in this area, representative soil samples from different depths and one groundwater sample (if encountered) will be collected/screened from each boring for on-site lab analysis. Samples will be screened for on-site analysis utilizing appropriate field instrumentation including a PID. The Harding ESE field geologist will also retain authority to analyze samples on the basis of visual/olfactory means.

If detectable PID readings <u>are</u> encountered for either of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for on-site VOC analysis. Furthermore, if evidence of VOC impacts is encountered at a boring location, an additional boring will be advanced at a location that is further east (hydraulically downgradient) of the initial location. This "step-out" process will be utilized to accurately delineate the horizontal extent of any VOC impacts. If unexpected field conditions are encountered, the Harding ESE field geologist and Boeing will discuss any recommended changes in sampling approach.

Boeing will collect representative soil samples from different depths for on-site lab analysis of VOCs. Samples will be screened for on-site analysis utilizing appropriate field instrumentation including a PID. If detectable PID readings <u>are</u> encountered for either of these soil borings, Boeing anticipates collecting a sample from the interval containing the highest PID reading and submitting it for on-site analysis. The Harding ESE field geologist will also retain authority to analyze samples on the basis of visual/olfactory means. One groundwater sample (if encountered) will be collected from each boring location using a temporary piezometer for on-site lab analysis of VOCs.

4.2.3 Groundwater Monitoring Tasks

Phase 2C groundwater monitoring tasks will be completed to delineate the horizontal/vertical extent of any VOC impacts to groundwater and document groundwater elevations across the Facility. Groundwater samples will be collected from 21 monitoring wells across the Facility (3 monitoring wells installed during Phase 2C; 9 monitoring wells that were installed during Phase 2B; 5 monitoring wells installed during Phase 2A; and 4 monitoring wells that were installed prior to July 2000. These samples will be evaluated for selected field criteria (temperature, pH, and conductivity) and then submitted for off-site analysis of VOCs.

Five of these groundwater samples (MW7, MW9-S, MW5, B25MW1, and B25MW4) will also be submitted for off-site analysis of RCRA metals (total and dissolved concentrations). One of these groundwater samples (B28MW1) will also be submitted for on-site analysis of ferrous iron and off-site analysis of other selected biodegradation parameters (total organic carbon [TOC], dissolved organic carbon, nitrate, nitrite, nitrate/nitrite as N, chloride, total iron, and sulfate).

Groundwater elevation and field parameter measurements will be performed for all of the monitoring wells and existing temporary piezometers installed during the Phase 2A, 2B, or 2C activities.

4.3 Supplemental Soil Investigation Tasks

Phase 2A/2B ESA analytical results for samples collected from the Facility indicate the presence of isolated constituent impacts to subsurface soils. Elevated VOCs were detected in soil samples beneath/adjacent to several portions of Building 27 and the only sampling location beneath Building 220. Detected VOCs included TCE and several associated degradation products (e.g. 1,2-DCE, vinyl chloride, 1,1-DCE, and 1,1-DCA). Elevated diesel petroleum hydrocarbons were detected in the soil sample to the east of Building 27 and the groundwater sample to the immediate north of Building 220.

Phase 2B analytical results largely defined the nature and extent of constituent impacts to subsurface soils at the Facility. As part of the Phase 2B investigation, no herbicide or pesticide impacts were detected in any of the soil samples collected adjacent to the railroad tracks along the north side of Banshee Road or to the west of Building 27 (B27W3). However, supplemental Phase 2C field investigation tasks are recommended at isolated areas (Recycling Area and southeast corner of Building 27) to further delineate any potentially impacted subsurface soils at these 2 areas.

4.3.1 Supplemental Soil Evaluation at Recycling Area

Phase 2A ESA analytical results for soil samples collected from the Facility indicate the presence of constituent impacts to soils at isolated portions of the Recycling Area to the west of Building 27. TCE and vinyl chloride concentrations exceeded the soil ITLs at 2 locations within the Recycling Area (RC1 and RC3). In addition, PCB levels exceeded groundwater ITLs at RC1 and RC2.

Phase 2B analytical results largely defined the horizontal and vertical extent of these constituent impacts. Soil concentrations exceeded ITLs for 1 additional sampling location (RC6). In addition, low TCE and vinyl chloride concentrations were detected at RC4. As a result, supplemental Phase 2C investigation tasks are recommended to more precisely define the horizontal extent of potentially impacted subsurface soil along the western edge of the Recycling Area. These supplemental tasks are summarized below.

<u>Evaluation of VOC Impacts at the Recycling Area</u>
Additional Geoprobe borings (RC9 and RC10) will be located within the Recycling Area to further delineate the horizontal/vertical extent of potential VOC impacts to subsurface soil and/or groundwater. Representative soil samples from different depths will be collected for on-site lab analysis of VOCs (RC9 and RC10) and off-site analysis of PCBs (RC9 only). The proposed soil sampling approach/locations for the Recycling Area are described in Section 3.2.1.2 due to the inter-related nature of the groundwater investigation tasks. Please review Section 3.2.1.2 for a detailed description of the soil investigation tasks at the Recycling Area.

4.3.2 Supplemental Soil Evaluation at Building 27

Phase 2A ESA analytical results for soil samples collected from the Facility indicate the presence of constituent impacts to soils at isolated areas beneath and surrounding Building 27. Elevated VOCs were detected to the west of Building 27 (hydraulically upgradient), beneath the northwest corner of Building 27 (B27I1), and to the east of Building 27 (hydraulically downgradient). TCE, vinyl chloride, and chromium exceed the soil ITLs at isolated locations in the vicinity of Building 27. The petroleum hydrocarbon level (extractable fraction) in the soil sample to the east of Building 27 (B27E2) also exceeds the soil ITL. As a result, various Phase 2B ESA field investigation tasks were completed to further evaluate the nature and extent of impacted soil in the vicinity of Building 27.

Evaluation of Petroleum Hydrocarbon Impacts Beneath Building 27

Additional Geoprobe borings (B27I10, B27I11) will be located within the southeast corner of Building 27 to help delineate the horizontal/vertical extent of potential petroleum hydrocarbon impacts to subsurface soil and/or groundwater. Representative soil samples from different depths will be collected for off-site lab analysis of TPH. The proposed soil sampling approach/locations for Building 27 are described in Section 3.2.1.3 due to the inter-related nature of the groundwater investigation tasks. Please review Section 3.2.1.3 for a detailed description of the soil investigation tasks at Building 27.

4.3.3 Supplemental Soil Evaluation at Building 28

As part of a separate UST removal effort, three 5,000-gallon jet fuel tanks are scheduled to be removed from an area adjacent to Building 28 (west of Building 27) in November 2000. Tank closure activities will be conducted in accordance with applicable Missouri UST regulations. In addition to routine sampling and analysis requirements, selected soil samples from the excavation floor and walls will also be submitted for VOC analysis to identify any potential impacts in the immediate vicinity of Building 28.

Table 4-1. Summary of Investigation Parameters for Phase 2C Activities

Building/Area ID	No. of Borings	Approx. No. of Soil Samples	No. of New Groundwater Monitoring Wells	No. of Groundwater Samples (incl temporary piezometers)	Target Analytical Constituents	SW846 Method	Sample Selection Criteria	Projected Sampling Intervals	Investigation Method	Projected Boring Depth*	Comments
East of Building 27 (Evaluation of VOC Impacts)	2	2	1 (1 shallow MW)	2	VOCs RCRA Metals (8)	8260 6010, 7060 7471, 7740	Highest PID &/or Visual Determination	Variable (see Section 3.2 for specific intervals)	Geoprobe and HSA	20 ft for soil borings & shallow MW; 60 ft for deep MW	50 ft horizontal step-outs if TCE/VOC impacts are evident.
East of Building 27 (Evaluation of Chromium Impacts)	5	5	2 (2 shallow MWs)	5	VOCs RCRA Metals (8)	8260 6010, 7060 7471, 7740	Metals - Staining VOCs - Highest PID/ Greatest Depth	Variable (see Section 3.2 for specific intervals)	Geoprobe and HSA	20 ft for soil borings & shallow MW; 60 ft for deep MW	50 ft horizontal step-outs if TCE/VOC impacts are evident.
Southeast Corner of Building 27	2	2	0	2	TPH	OA1 & OA2	Visual Determination &/or Highest PID	Variable (see Section 3.2 for specific intervals)	Geoprobe	24 ft for shallow borings	
Recycling and Hazardous Waste Areas	2	2	0	2	VOCs RCRA Metals Biodegrad Parameters PCBs *	8260 6010, 7060 7471, 7740 8081	Highest PID &/or Visual Determination	Variable (see Section 3.2 for specific intervals)	Geoprobe	16 ft for shallow soil borings; 30 ft for Dual Tube borings	Horizontal step-outs if TCE/VOC impacts are evident. * Only RC9 will be submitted for PCB analysis.
East of Building 220	2	2	0	2	VOCs	8260	Highest PID &/or Visual Determination	Variable (see Section 3.2 for specific intervals)	Geoprobe	20 ft for shallow borings	
Total	13	13	3	13							

* Vertical delineation depth subject to field modifications.

5.0 Sampling and Analysis Procedures

This section describes the pertinent sample collection, monitoring well installation, and laboratory analysis procedures.

5.1 Direct Push Sampling Technology

5.1.1 Soil Sampling

Direct push/hydraulic soil probe (Geoprobe) subsurface sampling equipment will be utilized as the primary drilling methodology wherever site conditions permit its use. Geoprobe equipment will be mounted on a Bobcat or all-terrain vehicle (ATV) for subsurface investigations.

The hydraulic soil probe technology utilizes static and percussion forces to drive probing and sampling tools into the subsurface. The thin-walled soil sampling tube remains completely sealed as it is driven to the desired sampling depth by steel probing rods. An internal piston is then manually released allowing soil to enter the sampling tube, which is lined with a disposable polybutylate (acetate) liner. The sampling tube is then driven further to collect the soil from the desired depth interval. The sampling tube is withdrawn and the polybutylate-encased sample is removed from the sampling tube.

An aliquot of sample will be placed directly into the appropriate sample container from each sampling location. No compositing of samples shall be performed. The samples collected for VOC analysis will be filled to the top of the jar to minimize the amount of headspace in the jar which may result in the loss of volatile compounds from the sample. Samples collected for organic analysis shall be immediately placed into an iced sample cooler to prevent the loss of volatile compounds. Soil samples acquired for metals analysis will be collected by placing an aliquot of soil into an appropriate glass sample container. Sample container requirements are described in the previous Quality Assurance Project Plan (QAPP).

To prevent cross-contamination between samples, the sampler shall wear disposable latex gloves during the collection of the samples. The sampler shall don a new pair of disposable gloves before collecting each sample. Also, the sampler shall decontaminate the sampling devices prior to each use. Decontamination procedures are discussed in the QAPP.

Following completion, each boring will be grouted with granular bentonite to surface and hydrated. Each boring will be sealed at the surface with concrete or asphalt. Soil cuttings will be containerized in 55-gallon DOT-approved drums and stored for subsequent disposal as discussed in the QAPP. Any decontamination liquids generated will be disposed of at the IWTP.

5.1.2 Groundwater Sampling

Due to the limited availability of shallow groundwater for numerous locations across the Facility, temporary piezometers will be used to collect groundwater samples from the shallow soil borings. Each temporary piezometer will be constructed of 1-inch diameter PVC with flush-threaded joints. Five-foot screen sections will be utilized at the bottom of each installation. Each temporary piezometer will be installed to an approximate completion depth of 16-20 ft bls.

Prior to the collection of groundwater samples, each temporary piezometer will be purged using a disposable polyethylene mini-bailer. Due to the limited availability of groundwater in the shallow water-bearing unit, each temporary piezometer will be purged by removing one well casing volume of groundwater. Upon completion of the purging process, groundwater samples will be collected using either a dedicated bailer (VOCs or metals), or a peristaltic pump (metals only).

5.2 Monitoring Well Installation Procedures

Monitoring wells will be installed in accordance with standard hollow-stem auger (HSA) drilling methods using 8 1/4-inch (or 4 1/4-inch) internal diameter (ID) hollow-stem augers. Prior to drilling at the initial and all subsequent borings, ancillary rig equipment will be cleaned using a high pressure cleaner wash at the temporary on-site decon station to eliminate cross-contamination between successive drilling locations.

During the monitoring well installation process, soil samples will be collected at select locations/ intervals for field screening, lithographic description, and potential chemical analysis. Soil samples will be collected using either a Lasky (5' x 4") core barrel or a split spoon (2' x 2") sampler. (One 60-ft Geoprobe boring may be completed prior to initiating the 2 HSA borings to fulfill the sample collection requirements and enhance the efficiency of the monitoring well installation process.) Each sampler will be opened and immediately scanned with a PID and/or FID to identify potential presence of VOCs. To maintain lithographic descriptive consistency, each soil sample will be described and classified in accordance with the Unified Soil Classification System (USCS).

Each monitoring well will be installed in accordance with the QAPP and the following general protocols:

1) Each monitoring well will be constructed of 2-inch diameter PVC with flush-threaded joints. Ten foot screen length sections (0.010-in slot) will be installed within each well.

2) The artificial sand pack will consist of chemically inert, rounded, silica sand and will be placed to a height of approximately two feet above the top of the screen.

3) A bentonite chip seal three feet in thickness will be placed above the sand pack material. Potable water will then be added to the borehole to hydrate the bentonite.

4) At least four hours after the bentonite seal is hydrated, the annular space above the bentonite seal will be sealed with cement/bentonite grout.

5) Each monitoring well will be completed with a flush-mounted, water-tight protective casing.

6) Well construction details will be recorded on standard field forms.

Special installation procedures will be utilized for all deep monitoring wells that are installed to the bedrock surface to ensure that cross-contamination does not occur between the shallow and deep water-bearing units. Each deep well will be constructed by using 8-1/4" I.D. hollow stem augers to set a 10-inch casing at an approximate depth of 60 ft bls. The casing will be grouted from the bottom of the casing to ground level. After the grout has set, the boring will be advanced to total depth (approximately 70 ft bls) using 4-1/4" I.D. hollow stem augers.

After installation, all monitoring wells will be developed to ensure that particulate matter introduced into the formation from the drilling process is removed, and to ensure good hydraulic connection with the formation. Formation water and fines will be evacuated throughout the water column. A bailer or submersible pump will be moved up and down throughout the water column in the screened portion of the well to maximize water flow through the entire screened length. A surge block may be used to facilitate flow of water into the formation between withdrawal periods.

Development procedures will be continued until one of the following criteria is met:

- Removal of a minimum of three well casing volumes or until the well is dry; or
- Stabilized measurements of pH, temperature, and specific conductance are recorded (e.g. consecutive field readings within 10 percent of each other).

5.3 Field Screening and Sample Selection Procedures

Each soil sample will be screened in the field with a PID for total organic vapors (TOV) by the headspace method. This process will involve placing a portion of the soil sample into a resealable plastic bag and allowing time for volatilization, if any, to occur. The PID probe will then be inserted into the plastic bag. The highest PID reading measured for the initial 10-second period will be recorded on the boring log form in units of parts per million (ppm).

The PID will be calibrated at a minimum of once per day during the Phase 2 ESA field effort. Instrument calibration will be performed in accordance with the manufacturers' recommended procedures using either commercially available or laboratory-provided calibration standards. All calibration data will be recorded in the Field Equipment Calibration Logbook.

5.4 Sample Collection Procedures

Samples will be collected and selectively submitted for on- and off-site chemical analysis of VOCs, petroleum hydrocarbons, and metals according to the target constituent list identified for each area. The proposed analytical parameters were selected based on Phase 2A ESA results and knowledge of chemical usage at the Facility.

5.4.1 Soil Sampling

Soil samples will be collected from selected borings/intervals for lab analysis using the 4-ft Macro-Core Geoprobe sampler, Lasky core barrel, or split spoon sampler. In the event that coarse gravel fill material is encountered below the concrete and collection of sufficient soil volume is not possible, the borings will be advanced until finer-grained materials (e.g. sand, silt or clay) are encountered, and the sample then collected.

The results of the field screening (PID, visual observation) will be utilized in the selection of sample intervals. The sample with the highest TOV level will be submitted for chemical analysis. Visual observations by the field geologist will also be considered in the sample selection process. <u>Refer to Sections 4.2 and 4.3 for site-specific screening criteria and anticipated sample depths.</u>

5.4.2 Groundwater Sampling

Water level measurements will initially be performed using an electronic water level probe and measured to the nearest 1/100 foot. Data will be recorded in a field notebook and subsequently transferred to a standard monitoring form.

Prior to the collection of groundwater samples, each monitoring well will be purged using a downhole submersible pump or a disposable polyethylene bailer. Each monitoring well will be purged by removing a minimum of three well casing and sand pack volumes of groundwater and obtaining stabilized field parameter readings, or until dry. If groundwater is turbid after completion of the well purging process, the silt/clay particulates will be allowed to settle prior to initiating sample collection activities. A settling period of 1-6 hours is anticipated. Groundwater will subsequently be sampled/collected from the top of the water column. These measures will serve to minimize sample turbidity, thus enhancing the accuracy of the associated analytical results.

The following collection procedures will be observed when using a bailer to sample a groundwater monitoring well:

- Lower the bailer slowly to the interval from which the sample is to be collected.
- A determined effort will be taken to minimize disturbance of the water column when raising and lowering the bailer in order to prevent aeration of the water column.
- Sample bottles will be filled by allowing the water to flow out the valve in the bottom of the bailer and into and along the side of the sample bottle.

The following constraints will also be observed when using a bailer:

- Only bottom-filling HDPE bailers or bailers made of other inert materials will be used.
- Only unused, decontaminated, or dedicated bailer line will be used.
- A reel upon which the bailer line may be wound is helpful (but not required) in lowering and raising the bailer. It also reduces the chance of contamination.

5.5 Quality Assurance/Quality Control Samples

In accordance with the Phase 2 ESA QAPP, one duplicate soil sample will be collected and analyzed per twenty soil samples. The duplicate soil samples will be analyzed for the location-specific target list of VOCs, petroleum hydrocarbons, and/or metals. Similarly, one duplicate groundwater sample will be collected for the groundwater monitoring event and submitted for off-site lab analysis.

5.6 Sample Management, Preservation, and Chain-of-Custody Procedures

Upon collection, each sample will be managed according to the procedures described in this subsection. These procedures have been established in accordance with the QAPP. Appropriate USEPA analytical methods, sample preservation techniques, sample volumes, and holding times are also presented in the QAPP.

5.6.1 Sample Containers

Samples will be collected into sample containers which have been pre-cleaned and assembled to USEPA's Protocol "B". The volume of sample collected and the type of container used will be determined by the suggested volumes described in SW-846 for the particular analysis. A summary of the bottle requirements and sample volumes is included in the QAPP.

5.6.2 Sample Management

Immediately upon collection, each sample will be properly labeled to prevent misidentification. The sample labels will include the sample number, the sample location, the sample depth, the date sampled, the time sampled, the analyses to be performed, and the sample collector's name. The sample labels will be affixed to the sample jar immediately upon collection. The sample labels will be made of waterproof material and filled out with waterproof ink.

After labeling, the samples will be placed into an appropriate shipping container. Samples collected for organic analysis will be placed into a shipping container with sufficient ice or ice packs to maintain an internal temperature of four-degrees (4°) Celsius during transport to the laboratory. The samples will be appropriately packaged in the shipping container to minimize the potential for damage during shipment. A completed chain-of-custody form will be placed in each shipping container to accompany the samples to the laboratory. The shipping containers will then be sealed with several strips of strapping tape.

The sample containers will be transported to the designated off-site laboratory. Samples will be transported so that no more than 24 hours elapse from the time of collection to the time that the laboratory receives the samples. The method of sample shipment will be noted on the chain-of-custody forms accompanying the samples. Strict chain-of-custody procedures will be maintained during sample handling.

5.6.3 Preservation

Samples for organic analyses will be preserved by placing each sample immediately into a cooler with sufficient ice or ice pack material to maintain a temperature of 4-degrees (4°) Celsius or less during transport to the laboratory. Sample preservation is not required for soil samples collected for metals analysis. Hydrochloric and nitric acid will be added to groundwater samples that are being analyzed for VOCs and metals, respectively. The required sample preservation methods for the specific constituents are included in the QAPP.

5.6.4 Chain-of-Custody

A chain-of-custody program will be followed to track the possession and handling of individual samples from time of collection through completion of laboratory analysis. Copies of the chain-of-custody record will be retained in the permanent file for proper documentation. The chain-of-custody forms shall include at a minimum:

- Sample number;
- Date and time of collection;

- Sample type (e.g., soil, groundwater, etc.);
- Parameters requested for analysis;
- Signature of person(s) involved in the chain of possession; and
- Inclusive dates of possession.

5.7 Analytical Methods

Samples will be submitted to qualified on-site and off-site laboratories for analysis. Sample analyses shall be selectively conducted for VOCs, petroleum hydrocarbons, and metals as previously described in Section 3. Lab quality assurance/quality control procedures will comply with the requirements of the QAPP.

5.8 Equipment Decontamination Procedures

All drilling and sampling equipment will be decontaminated prior to initial use at the Facility. Decontamination of Geoprobe equipment and other pieces of equipment will be performed at the drilling locations. Rinsewaters will be collected into a bucket or drum.

To prevent possible cross-contamination between samples, all down-hole drilling tools and sampling equipment will also be decontaminated between boring locations. Hollow-stem augers will be steam-cleaned between boring locations. Decontamination procedures for Geoprobe rods and other non-dedicated sampling equipment will consist of a wash of an Alconox solution, a potable/tap water rinse, followed by a distilled water rinse.

5.9 Waste Collection and Disposal Procedures

Waste materials derived from the field investigation, such as drill cuttings, decontamination rinsewaters, and personal protective equipment, will be collected in DOT-approved 55-gallon drums. The collected waste materials will be segregated into drums based on waste medium (water, soils, etc.). Each drum will be clearly labeled to indicate the type and approximate volume of contents, source, accumulation start date, and signature of the person completing the label.

The drums will be stored at an on-site location that will not disrupt Facility activities, yet provide a sufficient degree of security to deter any tampering with their contents. Equipment decontamination rinsewaters will be transferred to the influent of the IWTP where they will be treated to meet discharge standards in a similar manner with the chemical process influent. Drums with solid materials will remain on-site until proper disposal arrangements are completed by Boeing.

5.10 Evaluation of Investigation Results

Investigation results will be evaluated and subsequently presented in the Phase 2 ESA Report as described in the previously prepared Phase 2 ESA Workplan. In addition, the revised Phase 2 ESA Report will also address the following issues:

- New data and findings associated with the supplemental investigation (Phase 2B) of the Facility will be incorporated in the revised Phase 2 ESA Report;
- Existing data tables and figures will be updated to reflect the results of the supplemental investigation and groundwater monitoring program;
- New contaminant isoconcentration maps and/or other visual representations will be prepared to depict the horizontal and vertical extent of contamination; and
- Risk assessment calculations/conclusions will be developed, as needed, to incorporate all relevant data that are acquired from the Phase 2A and 2B investigations.

5.11 Quality Assurance / Quality Control

Quality assurance and quality control (QA/QC) procedures for the supplemental investigation will be performed in accordance with the prior Phase 2 ESA Workplan and the associated QAPP. QA/QC measures for the supplemental Phase 2B investigation and laboratory analysis are described below.

5.11.1 Field Quality Assurance / Quality Control Measures

Quality assurance of the field data will be maintained by field team personnel who are involved with the collection and handling of the required data. Each individual is required to perform specific tasks and document the completion of each task. Field quality assurance/quality control for this project shall be maintained by proper documentation of the actual work performed including date of performed work, daily project tasks, sample locations, sample collection times, specific field observations, weather conditions, air monitoring results, and identification of assigned field personnel. Documentation of the work performed shall be in the form of a field log book maintained by the field supervisor.

Quality control of the field data will be maintained through the collection of duplicate, equipment blank, and trip blank samples. Analysis of these samples will facilitate an evaluation of the sample collection and handling procedures, as well as the reproducibility of the data.

One (1) soil duplicate sample will be acquired for every 20 samples collected, or a minimum of one (1) sample every day of field sampling activities, to allow an evaluation of the reproducibility of the data. Duplicate samples will be acquired by collecting a sample volume from a selected location which is equal to twice the typically required sample volume. The sample volume will be split and placed into appropriate sample containers to produce two (2) separate laboratory samples. Each sample will then be identified with a unique sample identification number and submitted for analysis of the same suite of constituents.

Based on the anticipated collection of 3 groundwater samples during the Phase 2C groundwater monitoring event, 1 field duplicate groundwater sample will be collected for laboratory analysis. The duplicate sample will be collected using the same method employed for the field samples. The sample volume acquired will be twice the typically required sample volume. Each sample will be identified with a unique sample identification number and analyzed for the same suite of constituents.

Field equipment blanks will not be collected since disposable sample liners are being utilized for the soil sampling efforts. Similarly, equipment blanks will not be required for the groundwater sampling efforts since new dedicated equipment will be utilized for each sample. Trip blanks will be utilized for groundwater monitoring events in which samples are submitted for lab analysis of VOCs.

5.11.2 Laboratory Quality Assurance/Quality Control Procedures

The selected laboratories (Mid-American TEG and Severn Trent Labs) will perform the laboratory analyses required by the scope of this RAP according to the specific procedures described in the QAPP. The QA/QC procedures shall be in accordance with USEPA's SW-846, Chapter 1, Quality Control which addresses such items as laboratory blank samples, replicate samples, spike samples, and instrument calibration data.

5.12 Health and Safety

All Phase 2 ESA investigation tasks performed at the Boeing Facility shall be conducted in accordance with the prior site-specific Health and Safety Plan (HASP) dated July 2000. The HASP will consider conditions relevant to the site and will be reviewed by Harding ESE's Health and Safety Officer. The HASP will comply with the Occupational Safety and Health Administrations (OSHA's) specifications contained in 29 CFR 1910.100. Harding ESE personnel and subcontractors involved in Facility investigation activities will read the HASP before beginning work at the Facility, as well as participate in daily health and safety meetings.

An acceptable health and safety program shall be implemented to protect the field personnel from the potential exposures associated with subsurface sampling. Elements of the Health and Safety Program include:

- Health and Safety Plan (HASP) prepared by Harding ESE personnel in coordination with Boeing safety/environmental personnel;
- 40-hour HAZWOPER training for field sampling team members;
- 8-hour supervisory training for team leader;
- Site-specific safety briefing; and
- Use of Level D protective equipment.

Boeing policies also specify an additional health and safety requirement. All Harding ESE and subcontractor personnel must read the Boeing *Vendor/Contractor Safety/Environmental Awareness Guide* prior to acquiring an approved contractors badge. The approval process must be completed prior to the commencement of any work at the Facility.

6.0 Development of Remedial Action Objectives

This section describes addresses the target areas, target compounds of concern, and the corresponding development of any remedial action objectives for the Facility.

6.1 Target Areas and Compounds

This section discusses the target areas for the remedial action effort and the compounds of concern that have been characterized in the Phase 2 ESA.

6.1.1 Target Areas

The portions of the site constituting the target areas include the area in the immediate vicinity of Building 27 and the area in the immediate vicinity of Building 220. The target areas are displayed in Figures 2-1 and 2-2. As described in Section 2, various Phase 2 ESA activities have been completed to characterize and delineate constituent impacts to soil and groundwater in each of these areas.

6.1.2 Target Compounds

The target compounds for remedial action at the Facility include: 1) VOCs (focused on 1,2-DCE, trichloroethene, perchloroethene, and vinyl chloride); 2) chromium, 3) PCBs, and 4) TPH. These target compounds were selected utilizing the Phase 2 ESA results described in Section 2.

Groundwater samples were analyzed unfiltered and reported as total metals. Analytical results of the metals concentrations in the soil and groundwater were generally consistent across the Boeing site. Groundwater collected from these probe locations indicated levels above investigative threshold levels (ITLs) at 22 of the probe sampling locations. The groundwater samples collected from actual groundwater monitoring wells identified a chromium issue east of Building 27 near B27E1, but did not identify metal concentrations above ITLs across the site. The metal concentrations for temporary piezometer locations that exceeded ITLs are associated with the turbidity of the samples collected and do not indicate a site-wide metals issue.

Additional data were collected to determine if the metals were naturally-occurring or if they were indeed caused by sample turbidity during sample collection. During the Phase 2B efforts, groundwater samples were collected from well locations B27E4 and RR5W for off-site analysis. (B27E4 is located on the east side of Building 27 and RR5W is located along the south side of Building 27.) Groundwater samples were collected and analyzed for metals using a filtered sample method (reported as dissolved metals) along with a non-filtered method (total metals). Analytical results for the groundwater sample from B27E4 did not indicate significantly different chromium levels between the filtered and unfiltered samples. In addition, two other metal constituents that were detected in the unfiltered samples were not detected in the filtered samples. These comparative results indicate that metal concentrations are most likely associated with sample turbidity and/or naturally-occurring levels. Unfiltered/filtered groundwater samples were also collected from RR5W for off-site analysis. In this instance, filtered sample metals concentrations were 30-50% less than the unfiltered sample metals concentrations. This further indicates that initial groundwater metals concentrations are attributable to particulate metal content in the samples.

The combined results of these sampling efforts indicate that metals do not represent a site-wide issue at the Facility. As a result, remediation alternatives for metals will continue to focus on chromium impacts identified east of Building 27 near B27E1.

6.2 Determination of Preliminary Remediation Objectives (PROs)

This section discusses media-specific remediation objectives for the Facility.

The previous sections established the potentially impacted target areas and compounds which need to be considered in developing the remedial action objectives for the site. Results from the site investigation activities indicate that subsurface soils and groundwater in the shallow water-bearing unit have been impacted by the Facility. As a result, the corrective action objectives will focus on source control and media cleanup measures.

In order to develop suitable corrective action objectives for the protection of human health and the environment, soils and groundwater were evaluated so that appropriate risk-based remediation objectives could be established. These objectives also establish the requirements for source control, the elimination or mitigation of potential exposure pathways for potentially impacted soils, the reduction of groundwater concentrations in the shallow water-bearing unit, and the mitigation of potential off-site migration of groundwater constituents. The preliminary remediation objectives (PROs) that have been established for soil and groundwater at the Facility are discussed below.

For the purposes of this RAP, preliminary cleanup objectives (PCOs) represent values which incorporate <u>both</u> risk-based action levels <u>and</u> site-specific background levels. PROs were derived for soils using Tier 1 levels specified in Cleanup Levels for Missouri (CALM), USEPA Region 9 Preliminary Remediation Goals (PRGs), USEPA Region 3 Risk-Based Concentration (RBC) Tables, and site-specific background levels. For determination of preliminary soil cleanup objectives, the most conservative regional/state risk-based value was selected as the PRO. For ubiquitous metals, the background concentration was utilized as the PRO if greater than the risk-based standard. Background values were derived from USGS-based regional background soil concentrations for St. Louis County (Geochemical Survey of Missouri, USGS, 1984).

PROs for groundwater were derived in a similar manner. For ubiquitous metals, the background concentration was utilized as the PRO if greater than the risk-based standard. Site-specific background groundwater conditions were derived from a prior sampling event for two monitoring wells (MW-A1 and MW-A8) along the western corridor of the Facility. Analytical results for these background wells and associated statistical mean values are summarized in Table 6-1.

Soil/groundwater PROs are presented in Tables 6-2 and 6-3, respectively, for the constituents detected in the Phase 2 ESA. These tables also include relevant Missouri CALM-based standards, various USEPA regional risk-based values (e.g. PRGs, RBCs), and regional/site-specific background levels, as appropriate.

During this intermediate phase of the corrective action process (e.g. RAP, CMS), these PROs will be utilized to guide the selection of an appropriate and feasible remedial alternative for the Facility. Potentially applicable technologies/alternatives will be evaluated based on their relative effectiveness to meet these preliminary objectives. Any proposed pilot studies will also be focused on achievement of the PROs.

In conjunction with the CMI process and the development of the detailed remedial design for the selected remedial alternative, Boeing will conduct a site-specific risk assessment to address actual site conditions, migration pathways, potential receptors, etc. The results of that site-specific risk assessment will be used to develop final remediation objectives for the Facility, which will be incorporated into the final remedial design and CMI documents. In addition, any newly promulgated risk-based standards (e.g. Missouri risk-based groundwater standards) will be evaluated in the development of the final remedial objectives.

In addition to the previously described site-specific preliminary remediation objectives, the following remedial action objectives were formulated:

1. Minimize exposure to subsurface soil and groundwater through direct contact, inhalation, or ingestion.

2. Minimize the potential release of constituents from subsurface soil into the underlying groundwater.

3. Reduce constituent concentrations in subsurface soil and groundwater in the shallow water-bearing unit.

4. Restrict off-site migration of groundwater constituents.

6.3 General Response Actions

To identify remedial technologies that could be used to meet the remedial action objectives, a series of general response actions has been developed. General response actions are defined as general measures that may be implemented to achieve the remedial action objectives. The general response actions serve to categorize technologies which may be pertinent to the source control and media cleanup measures identified in the remedial action objectives. Consistent with the remedial action objectives formulated for the target areas at the Boeing Facility, general response actions have been developed to identify technologies which would minimize releases, threats of release, or potential pathways of contaminant exposure. The following general response actions have been developed as the most logical available means that are to be considered for meeting the remedial action objectives.

General Response Actions:

- **Natural Attenuation** - Provides a baseline for comparison.
- **Institutional Controls** - Provides institutional restrictions on land access/usage and institutional means of assessing potential releases from the target areas.
- **Source Removal** - Provides measures to control or eliminate the potential release of constituents into the underlying groundwater.
- **Treatment** - Provides measures to reduce the constituent concentrations in the subsurface soils and groundwater.

The following section evaluates the remedial technologies that are applicable to the general response actions.

TABLE 6-1

Summary of Mean Constituent Concentrations for Groundwater Samples from Background Monitoring Wells
Boeing RAP

CONSTITUENT	UNITS	BACKGROUND WELL NO. AND MEAN CONSTITUENT CONCENTRATIONS		MEAN
		MW-A1	MW-A8	
Metals/Inorganics (Total)				
Arsenic	mg/L	0.040	0.229	0.135
Barium	mg/L	1.990	3.050	2.520
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	0.120	0.360	0.240
Lead	mg/L	0.059	0.349	0.204
Mercury	mg/L	<0.0002	<0.0002	<0.0002
Selenium	mg/L	<0.05	<0.05	<0.05
Metals/Inorganics (Filtered)				
Arsenic	mg/L	0.021	0.020	0.021
Barium	mg/L	0.504	0.383	0.444
Cadmium	mg/L	<0.005	<0.005	<0.005
Chromium	mg/L	<0.01	<0.01	<0.01
Lead	mg/L	<0.005	<0.005	<0.005
Mercury	mg/L	<0.0002	<0.0002	<0.0002
Selenium	mg/L	<0.005	<0.005	<0.005

Footnotes:

1 Background Groundwater Concentrations are represented by the following statistical values:

- For parameters detected within the background groundwater samples, the statistical value is the mean background concentration.
- For parameters NOT detected within the background groundwater samples, the statistical value presented is the detection limit.

Table 6-2
Determination of Preliminary Remediation Objectives (PROs) for Soils (values in ug/kg except metals)
Boeing RAP

Constituent	BOEING Preliminary Remediation Objectives (PRO) for Soil (1)	Missouri CALM Industrial Scenario C (2)	Missouri CALM Leaching to Groundwater (3)	EPA Region 9 Preliminary Remed Goals (PRGs) (4)	CERCLA Soil Screening Levels (SSLs) (5)	USGS-Based Regional Background Concentration (6)
VOLATILE ORGANIC COMPOUNDS (VOCs)						
Acetone	**14,000**	8,660,000	14,000	6,200,000	16,000	--
Benzene	**30**	16,000	57	1,500	30	--
2-Butanone (MEK)	**28,000,000**	--	--	28,000,000	--	--
Carbon disulfide	**21,000**	21,000	52,000	720,000	32,000	--
Chloroform	**520**	5,800	864	520	600	--
1,1-Dichloroethane	**23,000**	--	--	2,100,000	23,000	--
1,1-Dichloroethene	**60**	--	--	120	60	--
1,2-Dichloroethene (total)	**400**	910,000	510	150,000	400	--
Ethylbenzene	**13,000**	1,460,000	55,000	230,000	13,000	--
4-Methyl 2-pentanone (MIBK)	**2,900,000**	--	--	2,900,000	--	--
Methylene chloride	**20**	145,000	21	21,000	20	--
Tetrachloroethene	**60**	160,000	420	19,000	60	--
Toluene	**5,130**	890,000	5,130	520,000	12,000	--
1,1,1-Trichloroethane	**2,000**	1,520,000	4,670	1,400,000	2,000	--
1,1,2-Trichloroethane	**20**	14,000	49	1,900	20	--
Trichloroethene	**60**	81,000	97	6,100	60	--
Vinyl Chloride	**10**	540	16	830	10	--
Xylenes, Total	**55,000**	1,510,000	55,000	210,000	200,000	--
Volatile Petroleum Hydrocarbons	**1,000,000**	1,000,000	--	--	--	--
Diesel Petroleum Hydrocarbons	**1,000,000**	1,000,000	--	--	--	--
POLYCHLORINATED BIPHENYLS (PCBs)						
Aroclor 1254	**1,000**	2,500	--	--	1,000	--
METALS/CYANIDE (mg/kg)						
Arsenic	**77**	14	--	440.00	0.4	77.0
Barium	**1,750**	9,040	1,650	100,000.00	1,600.0	1,750.0
Cadmium	**8**	300	11	810.00	8.0	ND
Chromium	**85**	2,700	38	450.00	38.0	85.0
Lead	**660**	660	--	750.00	400.0	85.0
Mercury	**2.00**	250	3	610.00	2.0	0.97
Selenium	**4.37**	970	4.37	10,000.00	5.0	2.5
Silver	**34**	1,160	255	10,000.00	34.0	NA

Listed constituents were detected in the ESA.
-- Applicable value not available.

Footnotes:
1 Preliminary Remediation Objectives (PROs) for soils were derived from Cleanup Levels for Missouri (September 1998) and other regional risk-For ubiquitous metals, the background concentration was utilized as the PRO if greater than the risk-based criteria.
2 Cleanup Levels for Missouri, September 1998. Value represents most representative of 3 exposure pathways (Industrial or Scenario "C").
3 Cleanup Levels for Missouri, September 1998. Value that is protective of "leaching to groundwater."
4 EPA Region 9 Preliminary Remediation Goals (PRGs), November 1, 2000.
5 Soil Screening Levels, July 1996. Value represents most conservative of 3 exposure pathways including ingestion, inhalation, and migration to groundwater (DAF of 20).
6 USGS-Based Regional Background Soil Concentrations (1984) for St. Louis County.

Table 6-3

Determination of Preliminary Remediation Objectives (PROs) for Groundwater (ug/l except TPH)

Boeing RAP

Constituent	BOEING Preliminary Remediation Objectives (PRO) for Groundwater (1)	Missouri CALM Groundwater Target Conc (GTARC) (2)	USEPA Drinking Water Standards (MCLs) (3)	EPA Region 9 Preliminary Remed Goals (PRGs) (4)	EPA Region 3 Risk-Based Concentrations (RBCs) (5)	Background Groundwater Concentration (6)
VOLATILE ORGANIC COMPOUNDS (VOCs) (ug/l)						
Acetone	**4,000**	4,000	4,000	610	610	--
Benzene	**5**	5	5	0.35	0.32	--
Bromodichloromethane	**80**	--	80	0.18	0.17	
Dibromochloromethane	**80**	100	80	0.13	0.13	
2-Butanone (MEK)	**1,900**	--	--	1,900	1,900	--
Carbon disulfide	**4,000**	4,000	4,000	1,000	1,000	
Carbon tetrachloride	**5**	5	5	0.17	0.16	
Chloroform	**80**	100	80	0.16	0.15	
1,1-Dichloroethane	**800**	--	--	810	800	--
1,1-Dichloroethene	**7**	7	7	0.046	0.044	--
1,2-Dichloroethene (total)	**70**	70	70	61	55	--
Ethylbenzene	**700**	320	700	1,300	1,300	--
2-Hexanone	**1,500**	--	--	--	1,500	
4-Methyl 2-pentanone (MIBK)	**140**	--	--	160	140	
Methylene chloride	**5**	5	5	4.3	4.1	--
Tetrachloroethene	**5**	5	5	1.1	1.1	--
Toluene	**1,000**	150	1,000	720	750	--
1,1,1-Trichloroethane	**200**	200	200	540	3,200	--
1,1,2-Trichloroethane	**5**	5	5	0.20	0.19	--
Trichloroethene	**5**	5	5	1.6	1.6	--
Vinyl chloride	**2**	2	2	0.041	0.040	--
Xylenes, Total	**10,000**	320	10,000	1,400	12,000	--
Volatile Petroleum Hydrocarbons	**10**	10	--	--	--	--
Diesel Petroleum Hydrocarbons	**10**	10	--	--	--	--
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)						
Benzo(a)anthracene	**0.10**	0.10	--	0.092	0.092	--
Chrysene	**10**	10	--	9.2	9.2	--
POLYCHLORINATED BIPHENYLS (PCBs)						
Aroclor 1254	**0.5**	0.5	0.5	0.034	0.033	--
METALS / CYANIDE						
Arsenic	**135**	50	5	0.045	0.045	135
Barium	**2,520**	2,000	2,000	2,600	2,600	2,520
Cadmium	**5**	5	5	18	18	5
Chromium	**240**	100	100	110	110	240
Lead	**204**	15	15	--	--	204
Mercury	**2**	2	2	11	--	0.2
Selenium	**50**	50	50	180	180	50
Silver	**100**	100	100	180	180	NA

Listed constituents were detected in the ESA.

-- Applicable value not available.

Footnotes:

1 Preliminary Remediation Objectives (PROs) for groundwater were derived from Cleanup Levels for Missouri (CALM) and USEPA Drinking Water Standards. For constituents CALM or MCL values were not available, regional risk-based standards were utilized as the PRO. For metals, the background concentration was utilized as the PRO if greater than the CALM, MCL, or regional risk-based standards.

2 Cleanup Levels for Missouri, September 1998. Value represents industrial exposure pathway (Industrial or Scenario "C").

3 Maximum Contaminant Levels, Summer 2000, non-zero MCLG, MCL, or HBL.

4 EPA Region 9 Preliminary Remediation Goals (PRGs), November 1, 2000.

5 EPA Region 3 Risk-Based Concentration (RBC) Tables, October 5, 2000.

6 Background Groundwater Concentrations are represented by the following statistical values:
- For parameters detected within the background groundwater samples, the value is the mean background concentration.
- For parameters NOT detected within the background groundwater samples, the value is the detection limit.

7.0 Identification and Screening of Remedial Technologies

This section presents the identification and screening of remedial technologies for applicability to the Boeing Facility.

7.1 Initial Range of Remedial Technologies

Based on their applicability to the general response actions presented in Section 5.4, a range of potential remedial technologies was initially identified. The range of potential technologies was initially examined to meet the remedial action objectives, as described in the document entitled, "Corrective Action: Technologies and Applications" (EPA/625/4-89/020, September 1990). This remediation technology information was utilized as the basis for further screening in the RAP.

The identified remedial technologies are those technologies that could fulfill the remedial response objectives. The identified remedial technologies are further categorized into their process option components. Process options refer to the specific processes available within a remedial technology.

The following subsections identify the screening criteria and then describe, evaluate, and screen the remediation technologies that have been identified and retained as applicable to the Facility.

7.2 Screening Criteria

After specific technologies were assembled, each technology was screened using the criteria recommended in the USEPA RCRA Corrective Action Plan guidance document (OSWER Directive 9902-3-2A, May 1994). The purpose of this screening step was to eliminate those technologies that are infeasible to implement, that rely on other technologies which are unlikely to perform satisfactorily or reliably, or that will not achieve the remedial objectives in a reasonable time period. The following information was used in evaluation and screening of the technologies:

- Site Characteristics
- Waste Characteristics
- Technology Limitations

Specific technologies were first screened to eliminate those that are ineffective or impossible to construct at the site. Administrative factors such as permits, available treatment capacity at off-site facilities, available equipment, and skilled labor were also considered. Site characteristics were reviewed to identify any site conditions that may preclude the use of specific technologies. Waste characteristics were also reviewed to establish if any of these traits limit the effectiveness or feasibility of the technologies. Those technologies that were limited by the site-specific waste characteristics at Boeing were eliminated. Technology limitations may also restrict a technology's effectiveness on any given site, and technologies that were unreliable, showed poor performance records, or were not fully demonstrated were eliminated from further consideration if a more acceptable technology or process option was available.

The criteria identified in the following sections were utilized to conduct the technology screening process.

7.2.1 Effectiveness

Effectiveness is given the most importance in this technology evaluation process. Effectiveness is defined as the degree to which a technology can attain the corrective action objectives, ensure the protection of human health and the environment during its implementation, and be considered reliable and proven with respect to the constituents of concern and conditions at the site.

7.2.2 Implementability

Implementability, which considers both technical and institutional implementability, is defined as the ability of a given technology to be compatible with the constituents and conditions at the site, the ability to obtain any necessary permits, the availability of treatment, storage or disposal capacity, and the availability of required equipment and trained personnel.

7.2.3 Cost

The cost evaluation criterion plays a limited role in the technology screening process. However, the relative capital, operation and maintenance costs associated with each given technology are the basis for comparison. Relative costs presented in this section are estimated on the basis of engineering judgement, and each process is evaluated relative to the process options in the same technology type. These relative costs are presented as low, medium or high.

7.3 Screening of Remedial Technologies

The remedial technology process options which would be ineffective in meeting the remedial action objectives, difficult to implement at the site, or prohibitively expensive relative to the other process options for a remedial technology have been eliminated from further consideration and are not discussed further in this text. Section 6.4 discusses the remedial technologies and their respective process options that have been identified, screened, and retained for further consideration at the site.

7.4 Discussion of Applicable Remedial Technologies

This subsection presents a brief, generalized discussion of the remedial technologies and their respective process options that are applicable for inclusion as a remedial alternative for the Boeing site. Detailed, site-specific applications of these technologies are presented in Section 8 with the detailed alternative descriptions. The remedial technologies are grouped in accordance with the general response action categories.

7.4.1 Natural Attenuation

Natural subsurface processes such as volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials are allowed to reduce contaminant concentrations to acceptable levels. Natural processes of contaminant degradation will reduce contaminant concentration levels before potential exposure pathways are completed. In addition, long-term monitoring would be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives. This action is readily implementable. The "Natural Attenuation" technology option will be retained for further consideration.

7.4.2 Institutional Controls

7.4.2.1 Access Restrictions

Access restrictions could restrict entry to the site. Unauthorized entry to the target areas of the Facility is already controlled by advanced security measures and fencing around the perimeter of the site. Fencing around the periphery of the site prevents unauthorized entry and minimizes the potential for direct contact with the subsurface soil in the target areas. This remedial technology would not interfere with site operations and the associated maintenance costs are low. Access restrictions are retained for use at the Facility to be applied in those areas as necessary to guard against unauthorized entry. Because this remedial technology is effective and easily implementable, it is retained for further consideration.

7.4.2.2 Deed Restrictions

Deed restrictions could be applied at the Facility through the implementation of deed restrictions on future land use. Deed restrictions can be readily implemented on the local level and would offer long-term effectiveness at a minimal cost. The restrictions are effective for protecting human health by controlling future land use.

Deed restrictions are retained for further consideration because they represent an effective technology that can be easily implemented.

7.4.3 Source Removal

Source removal consists of several different methods to physically remove the contaminants from the soil and/or groundwater. Excavation of the soil for off-site disposal, soil vapor extraction and air sparging are examples of source removal technologies that could be applied at the Boeing Facility.

7.4.3.1 Excavation

Excavation involves the physical removal of contaminated soil from a specific area. Soil and associated contaminants are removed thereby eliminating the source of contamination in the soil and eliminating the potential for migration to the underlying shallow water-bearing unit.

7.4.3.2 Soil Vapor Extraction

Soil vapor extraction (SVE) is an in-situ vadose zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semi-volatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on quantity emitted and local/state air discharge regulations. Extraction units are placed according to the radius of influence of the recovery unit.

7.4.3.3 Air Sparging

Air sparging is an in-situ technology in which air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. The injected air helps to flush the contaminants up into the unsaturated zone where a vapor extraction system is usually implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between ground water/soil and enhance the groundwater stripping process.

7.4.4 Groundwater Treatment

7.4.4.1 Iron Reactive Barrier Wall

A reactive barrier wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants. A reactive barrier wall consists of iron filings or other iron bearing minerals for the treatment of chlorinated contaminants such as TCE, DCE, and vinyl chloride. As the iron is oxidized, a chlorine atom is removed from the compound by one or more reductive dechlorination mechanisms, using electrons supplied by the oxidation of iron. The iron granules are dissolved by the process, but the metal disappears so slowly that the remediation barriers can be expected to remain effective for many years, possibly even decades.

7.4.3.3 HRC Injection

Chemical injection can be used as an in situ remediation technology to reduce constituent concentrations in soil and groundwater. One such technology involves HRC (Hydrogen Release Compound). HRC is a proprietary polylactate ester of Regenesis, Inc. that is specially formulated for slow release of lactic acid upon contact with water in the subsurface environment. HRC injection is designed to expedite the natural biodegradation process for subsurface soils and groundwater that have been impacted by chlorinated solvents.

Remediation of soil and groundwater using HRC injection typically involves installation of numerous injection points throughout the contaminated zone. This process involves the percolation or injection of this material to greatly enhance the reductive dechlorination process. The dechlorination process ultimately results in production of non-toxic compounds such as ethane or ethene.

Chlorinated solvents undergo biodegradation through three different pathways: 1) use as an electron acceptor (reductive dechlorination); 2) use as an electron donor (primary substrate); 3) co-metabolism where degradation of the chlorinated solvent provides no benefit to the microorganism but is simply fortuitous. In general, biodegradation of chlorinated solvents is an electron-donor-limited process.

The most important process for the natural biodegradation of chlorinated solvents is reductive dechlorination. The chlorinated solvent is utilized as an electron acceptor, and a chlorine atom is removed and replaced with a hydrogen atom. Because chlorinated solvents are utilized as electron acceptors during reductive dechlorination, an appropriate carbon source is required for microbial growth to occur. Reductive dechlorination has been demonstrated under nitrate- and sulfate-reducing conditions, but the highest rates of biodegradation occur during methanogenic conditions.

8.0 Development and Detailed Analysis of Remedial Alternatives

The preceding section identified the remedial technologies applicable to the general response actions that would be required to meet the Boeing corrective action objectives. By combining the applicable remedial technologies within the framework of the general response actions, four remedial alternatives have been developed. The developed alternatives are presented in the following section

8.1 Assembly of Remedial Alternatives

In order to identify an appropriate range of groundwater and subsurface soil management options that focus on source control measures, in accordance with the corrective action objectives, several viable remedial alternatives have been developed. The four remedial alternatives that have been developed are described and assessed separately within this section. The four remedial alternatives include:

Alternative 1: Natural Attenuation, Source Removal (Focused Excavation), and Institutional Controls

Alternative 2: Source Removal (Soil Vapor Extraction and Air Sparging; Focused Excavation), Natural Attenuation, and Institutional Controls

Alternative 3: Downgradient Groundwater Treatment (Iron Reactive Barrier Wall), Source Removal (SVE and Air Sparging; Focused Excavation), Natural Attenuation, and Institutional Controls

Alternative 4: Downgradient Groundwater Treatment (HRC Injection), Source Removal (HRC Injection, Focused Excavation), Natural Attenuation, and Institutional Controls

8.2 Screening of Remedial Alternatives

Assembled remedial alternatives are generally screened prior to conducting a detailed analysis of the alternatives. Through this initial screening, the number of remedial alternatives that are to be taken through detailed analysis can be reduced by screening out all except the most promising remedial alternatives. Discussed below are the remediation technology options that are the most promising with our site conditions and situation. The detailed analysis procedures and the descriptions/analyses for each remedial alternative are presented in the following sections.

8.3 Description of Detailed Analysis Criteria

In order to conduct a comprehensive, comparative analysis of the remedial alternatives, each of the alternatives were assessed against five evaluation standards. The five evaluation standards utilized are specified in the USEPA RCRA Corrective Action Plan guidance document (OSWER Directive 9902-3-2A, May 1994). The five evaluation standards are listed as follows:

1. Protection of human health and the environment;
2. Attainment of media cleanup standards;
3. Source control;
4. Compliance with applicable waste management standards; and
5. Other Factors.
   I) long-term reliability and effectiveness;
   ii) reduction in the toxicity, mobility, or volume of wastes;
   iii) short-term effectiveness;
   iv) implementability; and
   v) cost.

During the detailed analysis, each alternative was objectively assessed against each of the five standards. The guidance document recommends that the technical screening standards (standards 1-4 above) be given the most importance. The fifth standard (combination of technical measures and management controls) should be used to evaluate/select each alternative that satisfies the four technical standards. The selected remedial alternative, however, should be the alternative that in a cost-effective manner is most protective of human health and the environment. After analyzing the individual alternatives, a comparative analysis was then performed to assess the relative performance of each alternative with respect to the evaluation standards.

The evaluation standards to be used in analyzing the remedial alternatives are defined in the following sections.

8.3.1 Protection of Human Health and the Environment

Corrective action remedies must be protective of human health and the environment.

The human health evaluation focuses on the degree to which each alternative mitigates short- and long-term potential exposure to any residual contamination and protects human health, both during and after implementation of the remedy. This evaluation also includes a description of the levels of contaminants on-site, potential exposure routes, and potentially affected population.

The environmental evaluation of remedial alternatives focuses on facility conditions, pathways of contamination, short- and long-term beneficial and adverse effects, adverse effects on environmentally sensitive areas, and analysis of measures to mitigate adverse effects. Long-term protectiveness is evaluated based on the overall protectiveness the alternative provides after remedial actions are complete. Short-term protectiveness is evaluated to determine impact during the construction and implementation phases of the remediation.

8.3.2 Attainment of Media Cleanup Standards

Corrective action remedies are required to attain media cleanup standards set by the implementing agency. In some cases, technical aspects of the remedy (e.g. practical capabilities of a remedial technology) may influence the media cleanup standards that are established.

Evaluation of this standard focuses on the ability and effectiveness of each remedial alternative to meet the designated media cleanup standards or other remediation objectives. If a particular cleanup standard cannot be met by an alternative, then a determination should be made regarding the appropriateness of a waiver. An estimate of the timeframe necessary to attain the cleanup standards should also be included.

8.3.3 Source Control

Corrective action remedies must stop further environmental degradation by controlling or eliminating further releases that pose a threat to human health or the environment. Source control measures are essential for ensuring long-term effectiveness/protectiveness of the remedy.

Evaluation of this standard focuses on the necessity for source control measures and the type of control, if appropriate. The evaluation will address the known track record and predicted effectiveness of each source control technology.

8.3.4 Compliance with Applicable Waste Management Standards

Corrective action remedies are required to comply with applicable state or federal waste management regulations (e.g. closure requirements, land disposal restrictions). Evaluation of this standard focuses on the effects of local, state, and federal regulations, and environmental and public health standards on the design, operation and timing of each alternative. This criterion determines whether a remedial action alternative meets the federal and state standards that have been identified. If a particular standard cannot be met by an alternative, then a determination should be made regarding the appropriateness of a waiver.

8.3.5 Other Factors

Viable corrective action remedies are evaluated using five other general factors (long-term reliability and effectiveness; reduction in the toxicity, mobility, or volume of waste; short-term effectiveness; implementability; and cost).

8.3.5.1 Long-Term Reliability and Effectiveness

Evaluation of long-term reliability includes review of operation and maintenance requirements and potential risks associated with system failure. Technology effectiveness at similar sites, impact of technology failure upon receptors, and flexibility of the remedy to withstand uncontrollable conditions (e.g. heavy rainstorms, earthquakes, etc.) should be considered when evaluating this factor.

8.3.5.2 Reduction in Toxicity, Mobility, or Volume of Waste

Corrective action remedies that eliminate or substantially reduce waste constituents (e.g. treatment technologies) are generally preferred. Projections of pre- and post-remedial site conditions can also be utilized to evaluate this factor.

8.3.5.3 Short-Term Effectiveness

Short-term effectiveness is evaluated to determine potential impacts during the construction and implementation phases of the remediation effort. Impacts to on-site workers, nearby communities, or the environment and any necessary safety/protective measures associated with treatment, excavation, containment, or transportation should be considered when evaluating this factor.

8.3.5.4 Implementability

Evaluation of implementability is used to measure the relative ease of installation (constructability), assess the time required to implement a remedy, and estimate the time required to achieve beneficial results. Constructability includes the ability to obtain necessary approvals and/or permits from regulatory agencies; the availability of treatment, storage, or disposal services (including capacity); and the availability of equipment and trained personnel.

8.3.5.5 Cost

Evaluation of cost is used to estimate the capital costs, operation and maintenance (O&M) costs, and total present worth associated with implementing a remedial alternative.

The capital costs are divided into direct costs and indirect costs. Direct capital costs include construction costs, equipment costs, site development costs, and disposal costs. Indirect capital costs include engineering expenses, legal fees and license or permit costs, start-up costs and contingency allowances.

O&M costs are post-construction costs necessary to ensure the continued effectiveness of a remedial action. These costs include operating labor costs, maintenance materials and labor costs, auxiliary materials and energy. These costs also include disposal of residues, administrative costs, insurance and licensing costs, maintenance contingency funds, rehabilitation costs, and costs of periodic site reviews if required.

The cost estimates presented with this Remedial Action Plan report were developed utilizing the Remedial Action Costing Procedures Manual (USEPA 1985); Means Building Construction Cost Data (Means 1999); Means Site Work Cost Data (Means 1999) and quotations from various vendors and material suppliers. The costs estimates are expected to provide an accuracy of +50 to -30 percent.

After development of the capital and operation and maintenance costs, a present worth analysis of remedial action costs is conducted. A present worth analysis relates costs that occur over different time periods to present costs by discounting all future costs to the present value. This allows the cost of the remedial alternatives to be compared on the basis of a single figure that represents the money required in today's dollars to construct, operate and maintain the remedial alternatives throughout their planned life. For the purposes of this alternative evaluation process, the present worth values for implementing the alternatives are based on a discount rate of 10.5% and a performance period of 30 years (unless the lifetime of the alternative is less than 30 years). The assumed discount rate of 10.5% is consistent with the rate of return value that Boeing assigns to similar capital investment projects.

Utilizing the aforementioned five evaluation standards, each of the remedial alternatives has been taken through a detailed analysis. The results of these analyses are presented in the following sections.

8.4 Alternative 1: Natural Attenuation, Source Removal (Focused Excavation), and Institutional Controls

Alternative 1 provides for the continued reliance on natural attenuation and the additional implementation of focused excavation activities and institutional controls at the Facility. Natural attenuation would continue to reduce organic constituent concentrations in soil and groundwater via several ongoing biodegradation processes. Focused excavation efforts would be conducted to remove PCB-impacted soils in a localized area to the west of Building 27. As an institutional control measure, groundwater monitoring would be implemented to evaluate the ongoing biodegradation process and ensure against any off-site migration of constituents. Existing institutional controls including access restrictions would be continued. Deed restrictions would be implemented under this alternative to control future land usage.

8.4.1 Detailed Description

Alternative 1 would utilize natural attenuation to steadily improve the existing level of protection for human health and the environment. Natural attenuation involves natural biodegradation, volatilization, adsorption, or chemical reaction processes to reduce constituent concentrations in subsurface soils and groundwater, Based on site-specific analytical data from the Phase 2 ESA (e.g. the presence of chlorinated daughter products, high ratio of cis-1,2-dichloroethene isomer, low levels of competing anions, acceptable pH conditions, etc.), natural biodegradation (specifically anaerobic dechlorination) appears to be occurring at the target areas of the Boeing Facility. In addition, long-term soil/groundwater monitoring would be conducted throughout the duration of Alternative 1 to confirm that natural attenuation is proceeding at rates consistent with meeting site-specific cleanup objectives. If natural attenuation is selected for implementation at the Facility, detailed lines of evidence per USEPA Monitored Natural Attenuation guidance document (OSWER Directive 9200.4-17, 1997) would be provided in the CMI to estimate natural attenuation rates.

As part of Alternative 1, focused excavation activities would be conducted to remove PCB-impacted soil in the immediate vicinity of Soil Borings RC-1 and RC-2 (Recycle Center to the west of Building 27). Verification sampling would be conducted following the excavation activities to ensure that concentrations in the excavation side walls and floor meet the site-specific cleanup levels. Excavated soils would be transported off-site for disposal in accordance with appropriate state/federal regulations. These soil excavation activities would serve as a source removal measure and mitigate the potential for any future releases to the underlying groundwater.

As part of Alternative 1, a groundwater monitoring program would also be implemented to assess groundwater quality at the Facility. The groundwater monitoring program would utilize a majority of the monitoring wells that were installed since July 2000 and selected monitoring wells that were previously installed (wells between Building 27 and 28 and wells to the southeast of Building 27). The monitoring well network would initially be sampled on a quarterly basis for selected VOCs and biodegradation parameters. Groundwater elevation data would also be recorded to evaluate flow direction and gradient. Analytical results would be used to document progress of the natural attenuation process and ensure that downgradient constituents are not migrating off-site (e.g. verify that constituent concentrations meet acceptable standards before potential exposure pathways are completed). The groundwater monitoring program would be continued until site-specific cleanup standards are met. Additional details regarding any future groundwater monitoring program will be developed in conjunction with the CMI.

Under Alternative 1, existing institutional controls including access restrictions would be retained. Access restrictions at the Facility currently include a 8-ft fence with barbed wire, 24-hour security stations, and a perimeter lighting system. These measures would continue to be utilized and improved as necessary. Upkeep and periodic maintenance of the fence would be required. Deed restrictions would be added under Alternative 1 to control future land usage. If selected as the remedial alternative for the Facility, additional detail for Alternative 1 would be provided in the CMI.

8.4.2 Assessment

The results of assessing Alternative 1 against the five evaluation standards are presented below.

8.4.2.1 Protection of Human Health and the Environment

Protection of Human Health

The only potential current human exposure route associated with subsurface soils or groundwater from the target areas at the Facility is via inhalation of volatilized constituents through concrete floor slabs or pavement cover. Since utilization of the Facility is expected to remain the same in future years, the existing protection level of human health would be maintained. However, implementation of Alternative 1 would ensure that existing levels of protection are continued in the future.

Access restrictions provided under Alternative 1 would be effective in preventing unauthorized personnel from entering the Facility, thus, minimizing the potential for accidental exposure to the soil or groundwater at the target areas. Deed restrictions provided under Alternative 1 would supply supplemental protection of human health by controlling future land usage and eliminating inadvertent residential exposure routes in which human health might be jeopardized. Both access and deed restrictions would offer a high degree of long-term effectiveness in preventing Facility access and potentially unsafe land usage. Groundwater monitoring would be an effective method of verifying that future protection of human health is being accomplished. As a result, Alternative 1 would have a moderate degree of long-term effectiveness for protection of human health.

The principal human exposure pathways for potential migration of chemical constituents are direct contact, inhalation of volatilized constituents, leaching to groundwater, and ingestion of groundwater. As part of Alternative 1, natural attenuation would provide a reduction in the groundwater constituent concentrations. However, the improvement would be of marginal consequence since there is no exposure route for human contact or ingestion under current site conditions. As part of Alternative 1, access restrictions and deed restrictions would mitigate any potential adverse effects by preventing site access and eliminating residential land usage. In addition, current conditions already address these pathways. Direct contact with constituents from the target areas has been eliminated by pavement cover and buildings, and Facility grounds are well-buffered from surrounding land uses. The pavement cover and buildings significantly reduce potential migration via the inhalation pathway, but do not completely eliminate it. Thus, there is no exposure route for human contact or ingestion, but the current exposure pathway for inhalation of volatilized constituents still exists under Alternative 1.

Potential receptors include current and future site workers. This group includes any potential on-site or construction workers operating around or in the target areas. Potential long-term exposure could occur via inhalation of volatilized constituents. Short-term exposures to site workers by direct contact or inhalation could occur during construction activities that involve excavation or other subsurface activities. These short-term exposures could be readily addressed using appropriate safety precautions and containment of the operation. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring are defined in the health and safety plan as part of the remedial action process. Site-specific training to review these procedures would be performed prior to any such activities.

Since only limited on-site construction activities would be required as part of this alternative, Alternative 1 would have a high degree of short-term effectiveness. This is due to the fact that risks to human health would only be marginally increased during the implementation of Alternative 1.

<u>Protection of the Environment</u>

The principal environmental pathways of potential constituent migration from the source and downgradient areas, respectively, include: 1) leaching from soils into the underlying shallow groundwater, and 2) flow of groundwater within the shallow water-bearing unit to Coldwater Creek. Under Alternative 1, natural attenuation would reduce constituent concentrations in subsurface soil and shallow groundwater. However, due to the low groundwater flow gradient at the Facility, its short-term protectiveness of the environment may be limited.

As part of Alternative 1, groundwater monitoring would be effective in verifying that future protection of the environment is being accomplished. The groundwater monitoring program would be utilized to verify that groundwater constituents are not migrating off-site and impacting any potential receptors. As a result, Alternative 1 would have a moderate degree of long-term effectiveness for protection of the environment.

8.4.2.2 Attainment of Media Cleanup Standards

Under Alternative 1, reduction of soil/groundwater constituent concentrations within the target areas at the Facility would rely on natural attenuation and focused excavation of PCB-impacted soils. As previously described in Section 8.4.1, reduction of VOC concentrations via anaerobic dechlorination is already occurring at the Facility. The natural attenuation process will steadily decrease VOC concentrations in the impacted soils and groundwater. The effectiveness of this biodegradation process would continue into the future.

Aside from focused excavation of PCB-impacted soils, none of the other technologies included within Alternative 1 (natural attenuation, institutional controls) would enhance the potential attainment of soil/groundwater cleanup standards for chromium or PCBs.

Soil and groundwater concentrations for selected areas west of Building 27 do not presently meet the current PROs. Based on current groundwater concentrations present at the Facility and case studies with similar site conditions, attainment of groundwater cleanup standards will require an approximate 20-30 year period under Alternative 1 (natural attenuation).

State regulatory agency approval would be required prior to implementation of Alternative 1. Regulatory approval and community acceptance for Alternative 1 are uncertain since the alternative is unlikely to be protective of human health and the environment with respect to existing chromium and PCB concentrations. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.4.2.3 Source Control

Under Alternative 1, various source control measures would be continued or newly implemented. As an existing source control measure, impacted soils are currently covered by pavement and/or buildings thus eliminating any direct contact. Effectiveness of the pavement/building cover would continue into the future as long as current site conditions are maintained. Alternative 1 would also incorporate excavation of PCB-impacted soils as an additional form of source control/removal. Excavation of PCB-impacted soils is a proven and effective method of source control. Due to the 1) low horizontal flow gradient for groundwater in the shallow water-bearing unit, and 2) limited number of potential downgradient receptors, additional source control measures are not considered necessary.

8.4.2.4 Compliance with Applicable Waste Management Standards

State regulatory agency approval would be required prior to implementation of Alternative 1. Soil/groundwater constituent concentrations within the target areas at the Facility are being reduced via natural attenuation. However, these concentrations would still need to meet site-specific cleanup standards. Regulatory approval and community acceptance for Alternative 1 are uncertain since the alternative is unlikely to be protective of human health and the environment with respect to existing chromium and PCB concentrations. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.4.2.5 Other Factors

<u>*Long-Term Reliability and Effectiveness*</u>

Long-Term Reliability

The combination of natural attenuation, focused excavation, and groundwater monitoring methods under Alternative 1 provide a moderate degree of reliability. Each of these technologies represents a proven and established method. Failure of any technology within Alternative 1 would not have an immediate impact upon potential receptors due to the geological characteristics of the shallow water-bearing unit. In fact, the groundwater monitoring program effectively serves as a safeguard to evaluate any potential technology failures. Uncontrollable site changes (e.g. heavy rainstorms, earthquakes, etc.) would have a minimal effect on the long-term reliability of Alternative 1. While natural attenuation may be adversely influenced by variable subsurface conditions, the groundwater monitoring program will facilitate periodic evaluation of groundwater concentrations and any necessary modifications to the biodegradation process (nutrient addition, HRC injection, etc.).

Operation and maintenance requirements under Alternative 1 would be minimal. In addition to routine upkeep of the pavement cover, periodic sampling of the groundwater monitoring well network would be required. Groundwater monitoring results would be reviewed to evaluate compliance with allowable concentrations and the risk associated with groundwater in the shallow water-bearing unit. Sampling procedures would be documented to ensure the reliability of the groundwater monitoring program.

Long-Term Effectiveness

Alternative 1 would possess a high degree of long-term effectiveness. None of the associated technologies are likely to deteriorate with time. Each of the technologies under Alternative 1 would have a projected useful life that could be extended indefinitely into the future, if needed.

Impacted soils and groundwater are currently covered by pavement and/or buildings, thus eliminating any direct contact. Effectiveness of the pavement/building cover would continue into the future as long as current site conditions are maintained.

Focused excavation of PCB-impacted soils has a high degree of long-term effectiveness since the source material is being removed. Verification sampling of the excavation walls and floor would be conducted to ensure completeness.

The natural attenuation process will steadily decrease constituent concentrations in the impacted soils and groundwater. The effectiveness of this biodegradation process would continue into the future.

The groundwater monitoring program would provide an effective method for evaluating the long-term progress of the natural attenuation process and verifying the horizontal extent of groundwater constituents. This monitoring program also represents an effective method of verifying that groundwater constituents are not migrating off-site and impacting any potential receptors.

Regulatory agency approval of a natural attenuation program, focused excavation activities, and the groundwater monitoring program would be required. The time required to obtain regulatory approval would be nominal (approximately 90 days).

<u>*Cost*</u>

The costs associated with Alternative 1 are provided in Table 8-1. The capital costs for implementation of Alternative 1 are associated with excavation/disposal costs for PCB-impacted soils, the transactional cost related to acquiring any deed restrictions, and access maintenance costs including maintenance of the peripheral fences. Capital costs are estimated to be $437,000. Annual O&M costs of $87,000 are associated with the groundwater monitoring program. By applying a 10.5% discount rate over a 30-year implementation period, the total present worth of Alternative 1 is estimated to be $1,224,200. A summary of the costs associated with Alternative 1 is presented in Table 8-1.

8.5 Alternative 2: Source Removal (Focused Excavation, SVE and Air Sparging), Natural Attenuation, and Institutional Controls

Alternative 2 would consist of implementing various source removal actions to remediate selected portions of the target areas at the Facility. The principal method of source removal would involve the utilization of a soil vapor extraction (SVE) system with air sparging to remediate soil/groundwater within the target area to the immediate west of Building 27. The natural attenuation, focused excavation of PCB-impacted soils, and institutional control measures described for Alternative 1 in Section 8.4 would also be included in Alternative 2.

8.5.1 Detailed Description

Alternative 2 would utilize SVE with air sparging to remediate impacted soil and groundwater within the target area to the immediate west of Building 27. Soil vapor extraction (SVE) is an in-situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and semi-volatile constituents from soil. Installation of this remediation technology at the Boeing Facility would also include air sparging to enhance the removal of VOCs. Air sparging is an in-situ technology in which air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. The injected air helps to flush (bubble) the contaminants up into the unsaturated zone where SVE is usually implemented in conjunction with air sparging to remove the vapor phase constituents.

An SVE pilot study would be conducted within the target area to the immediate west of Building 27 to evaluate constituent concentrations, potential soil vapor removal rates, and other design-related parameters. Based on the SVE pilot study results, a full-scale SVE system with air sparging would be designed/installed. Depending on the outlet constituent concentrations, discharge flowrate, and applicable regulatory levels, treatment of the vapor effluent could be required.

The natural attenuation, focused excavation of PCB-impacted soils, and institutional control measures previously described in Section 7.4.1 would also be incorporated into Alternative 2. If selected as the remedial alternative for the Facility, additional detail for Alternative 2 would be provided in the CMI.

8.5.2 Assessment

The results of assessing Alternative 2 against the five evaluation standards are presented below.

8.5.2.1 Protection of Human Health and the Environment

Protection of Human Health

The only potential current human exposure route associated with subsurface soils or groundwater from the target areas at the Facility is via inhalation of volatilized constituents through concrete floor slabs or pavement cover. Since utilization of the Facility is expected to remain the same in future years, it is expected that the existing protection level of human health would be maintained. However, implementation of Alternative 2 would ensure that existing levels are improved in the future.

Existing pavement and building cover would reduce the amount of water infiltration into the subsurface soil. As previously described in Section 8.4.2 (Alternative 1), institutional controls would further ensure the continued protection of human health into the future by minimizing Facility access and controlling future land usage. Under Alternative 2, source removal via the SVE and air sparging system would reduce the risk of constituents leaching into the groundwater and further reduce potential exposure to the subsurface soil, although the current potential for such events is already very low. With the combination of source removal actions, natural attenuation, and institutional controls, Alternative 2 would have a high degree of long-term protection to human health.

The principal human exposure pathways for potential migration of chemical constituents are direct contact, inhalation of volatilized constituents, leaching to groundwater, and ingestion of groundwater. Under Alternative 2, source removal actions would provide a reduction in the soil/groundwater constituent concentrations. However, the improvement would be of marginal consequence since there is no exposure route for human contact or ingestion under current site conditions. As previously described in Section 8.4.2, (Alternative 1), natural attenuation would provide a reduction in the groundwater constituent concentrations. As part of Alternative 1, access restrictions and deed restrictions would mitigate any potential adverse effects by preventing site access and eliminating residential land usage. As previously indicated, current conditions already address these pathways. Direct contact with constituents from the target areas has been eliminated by pavement cover and buildings, and Facility grounds are well-buffered from surrounding land uses. The pavement cover and buildings significantly reduce potential migration via the inhalation pathway, but do not completely eliminate it. Thus, there is no exposure route for human contact or ingestion, but the current exposure pathway for inhalation of volatilized constituents still exists under Alternative 2.

Potential receptors include current and future site workers. This group includes any potential on-site or construction workers operating around or in the target areas. Potential long-term exposure could occur via inhalation of volatilized constituents. Short-term exposures to site workers by direct contact or inhalation could occur during construction activities that involve excavation or other subsurface activities. These short-term exposures could be readily addressed using appropriate safety precautions and containment of the operation. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring are defined in the health and safety plan as part of the remedial action process. Site-specific training to review these procedures would be performed prior to any such activities.

Under Alternative 2, construction activities would be required for installation of the SVE and air sparging system. Installation of the SVE system could pose a health risk and a safety hazard to workers if the subsurface soil and/or groundwater is not handled properly. Excavation activities prior to manifold installation would increase the potential short-term risks to human health (and the environment). To limit the dust that may be generated during the grading activities, the construction area would be sprayed intermittently with a fine mist of water as warranted by the existing weather conditions. Since the risks to human health (and the environment) may actually be increased during implementation of the SVE system, Alternative 2 would have a low degree of short-term effectiveness.

Protection of the Environment

The principal environmental pathways of potential constituent migration from the source and downgradient areas, respectively, include: 1) leaching from soils into the underlying shallow groundwater, and 2) flow of groundwater within the shallow water-bearing unit to Coldwater Creek. Under Alternative 2, the SVE and air sparging system would remove chemical constituents from the vadose zone of the source area to the west of Building 27.

As previously described in Section 7.4.2 (Alternative 1), natural attenuation and focused excavation would reduce constituent concentrations in subsurface soil and shallow groundwater. However, due to the low groundwater flow gradient at the Facility, its short-term protectiveness may be limited. As an additional component of this alternative, groundwater monitoring would be effective in verifying that future protection of the environment is being accomplished. Thus, institutional controls would offer a high degree of long-term protectiveness of the environment. With the combination of source removal actions, natural attenuation, and institutional controls, Alternative 2 would provide a high degree of long-term protectiveness of the environment.

8.5.2.2 Attainment of Media Cleanup Standards

Under Alternative 2, reduction of soil/groundwater constituent concentrations within the target areas at the Facility would rely upon SVE and air sparging methods, as well as natural attenuation. As previously described in Section 8.4.1, reduction of VOC concentrations via anaerobic dechlorination is already occurring at the Facility. The natural attenuation process will steadily decrease VOC concentrations in the impacted soils and groundwater. The effectiveness of this biodegradation process would continue into the future.

Aside from focused excavation of PCB-impacted soils, none of the other technologies included within Alternative 2 (SVE, air sparging, natural attainment) would enhance the potential attainment of soil/groundwater cleanup standards for chromium or PCBs.

Soil and groundwater concentrations in selected areas to the west of Building 27 do not presently meet the current PROs. Based on existing soil concentrations and site conditions, attainment of soil cleanup standards could be expected within approximately 2-3 years using the SVE and air sparging methods included under Alternative 2. However, based on current groundwater concentrations present at the Facility, attainment of groundwater cleanup standards via natural attenuation would still require an approximate 20-30 year period under Alternative 2.

State regulatory agency approval would be required prior to implementation of Alternative 2. Regulatory approval and community acceptance for Alternative 2 are uncertain since the alternative is unlikely to be protective of human health and the environment with respect to existing chromium and PCB concentrations. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.5.2.3 Source Control

Alternative 2 provides a high degree of source control by relying upon a combination of ongoing and newly implemented measures.

As an existing source control measure, impacted soils are currently covered by pavement and/or buildings thus eliminating any direct contact. Effectiveness of the pavement/building cover would continue into the future as long as current site conditions are maintained.

Under Alternative 2, SVE and air sparging would be used to effectively remove VOCs from the vadose zone of the source areas. SVE and air sparging represent proven source control technologies that are anticipated to work well given the existing conditions at the Facility.

As previously described in Section 8.4.2.3 (Alternative 1), excavation of PCB-impacted soils represents an additional form of source control/removal. Excavation of PCB-impacted soils is a proven and effective method of source control.

Due to the 1) low horizontal flow gradient for groundwater in the shallow water-bearing unit, and 2) limited number of potential downgradient receptors, additional source control measures are not considered necessary.

8.5.2.4 Compliance with Applicable Waste Management Standards

State regulatory agency approval would be required prior to implementation of Alternative 2. Under Alternative 2, soil/groundwater constituent concentrations within the target areas at the Facility would be reduced via SVE and air sparging, focused excavation of PCB-impacted soils, and natural attenuation. However, these concentrations would still need to meet site-specific cleanup standards. Due to potential air emission concerns, specific approval from the MDNR Air Pollution Control Program and/or St. Louis County Department of Health would also be required to install/operate the SVE system.

Regulatory approval and community acceptance for Alternative 2 are uncertain since the alternative is unlikely to be protective of human health and the environment with respect to existing chromium and

PCB concentrations. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.5.2.5 Other Factors

<u>*Long-Term Reliability and Effectiveness*</u>

Long-Term Reliability

The combination of source control (via SVE and air sparging), natural attenuation, focused excavation, and groundwater monitoring methods under Alternative 2 provide a moderate degree of reliability. Each of these technologies represents a proven and established method. Failure of any technology within Alternative 2 would not present an immediate risk due to the limited number of receptors, the limited number of pathways for migration, and the geological characteristics of the shallow water-bearing unit. In fact, the groundwater monitoring program effectively serves as a safeguard to evaluate any potential technology failures. Uncontrollable site changes (e.g. heavy rainstorms, earthquakes, etc.) would have a minimal effect on the long-term reliability of Alternative 2. While natural attenuation may be adversely influenced by variable subsurface conditions, the groundwater monitoring program will facilitate periodic evaluation of groundwater concentrations and any necessary modifications to the biodegradation process (nutrient addition, HRC injection, etc.).

The SVE and air sparging system proposed under Alternative 2 would require a moderate level of O&M activity. Periodic maintenance of the SVE/air sparging equipment and refinement of the operational parameters (e.g. vacuum flowrate, sparging pressure, etc.) would be required to ensure efficient operation of the system. A quarterly monitoring program of inlet and effluent vapors would also be developed to evaluate the effectiveness/acceptability of the removal effort. In addition, review of the soil vapor data would be conducted on an annual basis to substantiate the eventual shutdown of the SVE system and verify attainment of soil cleanup standards.

As previously described in Section 8.4.2 (Alternative 1), routine upkeep of the pavement cover and periodic sampling of the groundwater monitoring well network would be required. The quarterly groundwater monitoring program would facilitate periodic evaluations of constituent concentrations and any potential modifications to the biodegradation process, if needed. In addition, periodic review of the groundwater quality data would be conducted to evaluate attainment with the site-specific cleanup standards. A comprehensive O&M manual for the selected remedial alternative would address inspections and upkeep of the SVE system, as well as procedures for the groundwater monitoring program. O&M details for the selected alternative would be provided in the subsequent CMI.

Long-Term Effectiveness

Alternative 2 would possess an even higher degree of long-term effectiveness than Alternative 1 due to the added implementation of SVE with air sparging. This remedial technology would more rapidly remove constituents from the source area to the immediate west of Building 27 and therefore reduce the potential future leaching of constituents from soil into the underlying groundwater.

The effectiveness of SVE and air sparging decreases with time as the constituents are removed from the underlying vadose zone. Based on current site conditions and the site-specific cleanup standards for soil, SVE and air sparging are projected to have a useful life of approximately 2-3 years. As previously described in Section 8.4.2 (Alternative 1), none of the other technologies are likely to deteriorate with time. Each of the technologies under Alternative 1 would have a projected useful life that could be extended indefinitely into the future, if needed.

As previously described in Section 8.4.2 (Alternative 1), long-term effectiveness would be achieved under existing Facility conditions since the impacted soil and groundwater are currently covered, thus eliminating any direct contact. Focused excavation of PCB-impacted soils would also have a high degree of long-term effectiveness since the source material is being removed. The natural attenuation process would steadily decrease constituent concentrations in the impacted soils/groundwater into the future. Furthermore, the proposed groundwater monitoring program would provide an effective method of ensuring that downgradient constituents are not migrating off-site and impacting any potential receptors. With the combination of existing conditions, natural attenuation, institutional controls, and source removal, Alternative 2 would provide a high degree of long-term effectiveness.

<u>Reduction in Toxicity, Mobility, or Volume of Wastes</u>

Alternative 2 would provide a moderate degree of reduction in toxicity, mobility, and volume of wastes. SVE and air sparging would provide a significant reduction in the volume of VOCs from the source area to the immediate west of Building 27. Focused excavation of PCB-impacted soils would provide an immediate, but focused reduction in the volume of PCB constituents in the subsurface soil. However, neither of these methods represents a treatment technology. Natural attenuation would provide a gradual reduction in the toxicity and volume of groundwater constituents in the shallow water-bearing unit over time.

Short-Term Effectiveness

Under Alternative 2, significant construction activities would be required for installation of the SVE and air sparging system. Installation of the SVE system could pose a health risk and a safety hazard to workers if the subsurface soil and/or groundwater is not handled properly. Excavation activities prior to manifold installation would increase the potential short-term risks to human health (and the environment). To limit the dust that may be generated during the grading activities, the construction area would be sprayed intermittently with a fine mist of water as warranted by the existing weather conditions. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring would be defined in the health and safety plan as part of the subsequent CMI.

Since the risks to human health (and the environment) may actually be increased during implementation of the SVE system, Alternative 2 would have a low degree of short-term effectiveness.

Implementability

Installation of the SVE and air sparging system proposed under Alternative 2 would involve conventional construction techniques. However, due to site-specific conditions, installation of an underground SVE/sparging manifold system would be implemented with a moderate degree of difficulty. As described in Section 8.4.2 (Alternative 1), natural attenuation and institutional controls could be easily implemented. Natural attenuation is already occurring at the Facility, access restrictions are in place, focused excavation activities are routinely performed, and installation of the monitoring well network have all been completed. Each of these remedial actions represents a conventional and effective process.

Installation of the SVE and air sparging system under Alternative 2 utilizes conventional processes for which components can be readily completed. The necessary construction equipment and trained personnel would be provided by Boeing contractors. Specialists, construction materials, and additional equipment are readily available. As previously described in Section 7.4.2 (Alternative 1), natural attenuation, focused excavation, and institutional control methods would utilize standard processes for which components are either not required or can be readily obtained. Excavation equipment and off-site disposal services could be easily secured. The necessary groundwater monitoring equipment and trained personnel could be readily provided by Boeing or its contractors.

Regulatory agency approval of the SVE and air sparging system would be required. Following regulatory approval of the RAP, a SVE pilot test would be conducted prior to full-scale design. Due to potential air emission concerns, specific approval from the MDNR Air Pollution Control Program and/or St. Louis County Department of Health would also be required to install/operate the SVE system. Regulatory agency approval of a natural attenuation program, focused excavation activities for PCB-impacted soils, and the groundwater monitoring program would be required. The time required to obtain regulatory approval for all of the above activities would be moderate (approximately 180 days).

As a result of the potential SVE system complexities, Alternative 2 would only possess a moderate degree of implementability.

Cost

The costs associated with Alternative 2 are provided in Table 8-2. The capital costs for implementation of Alternative 2 are primarily associated with the SVE and air sparging system costs. Capital costs are estimated to be $4,124,300. Annual O&M costs of $119,400 are associated with the SVE and groundwater monitoring programs. By applying a 10.5% discount rate over a 30-year implementation period, the total present worth of Alternative 2 is estimated to be $4,991,200. A summary of the costs associated with Alternative 2 is presented in Table 8-2.

8.6 Alternative 3: Downgradient Groundwater Treatment (Iron Reactive Wall), Source Removal (SVE and Air Sparging; Focused Excavation), Natural Attenuation, and Institutional Controls

Alternative 3 would consist of installing an iron-based reactive barrier wall to intercept groundwater in the shallow water-bearing unit to the east of Building 27. The source removal actions described for Alternative 2 in Section 8.5 and natural attenuation/ institutional controls described for Alternative 1 in Section 8.4 would also be included within Alternative 3.

8.6.1 Detailed Description

The major aspect of Alternative 3 would involve the installation of an iron reactive wall within the shallow water-bearing unit to the east of Building 27. The projected length of the reactive wall would extend approximately 700 feet along a north-south line to the east of Building 27. The iron reactive wall would provide downgradient treatment of the shallow water-bearing unit as well as an additional mechanism for ensuring against the potential for any off-site migration.

Design studies for the iron barrier wall would be completed to further define the existing hydraulic conditions and determine the specific wall dimensions/construction. Due to the silty clay nature of the underlying soils, wall construction will be completed in approximate 25-ft sections using braced sheet piling. Piling would be driven to depth using a vibratory hammer. The iron barrier wall will be keyed into the underlying clay layer at a depth of approximately 30 ft bls. Each construction cell will be dewatered prior to placement of the iron material. The iron reactive wall would extend over an approximate length of 700 feet.

Source removal actions described in Section 8.5.1 (Alternative 2) would also apply to Alternative 3. Natural attenuation, focused excavation, and institutional controls described in Section 8.4.1 (Alternative 1) would also apply to Alternative 3. If selected as the remedial alternative for the Facility, additional detail for Alternative 3 would be provided in the CMI.

8.6.2 Assessment

The results of assessing Alternative 3 against the five evaluation standards are presented below.

8.6.2.1 Protection of Human Health and the Environment

Protection of Human Health

The only potential current human exposure route associated with subsurface soils or groundwater from the target areas at the Facility is via inhalation of volatilized constituents through concrete floor slabs or pavement cover. Since utilization of the Facility is expected to remain the same in future years, it is expected that the existing protection level of human health would be maintained. However, implementation of Alternative 2 would ensure that levels of protection are improved in the future.

Existing pavement and building cover would reduce the amount of water infiltration into the subsurface soil. As previously described in Section 8.4.2 (Alternative 1), institutional controls would further ensure the continued protection of human health into the future by minimizing Facility access and controlling future land usage. As previously described in Section 8.5.2 (Alternative 2), source removal via the SVE and air sparging system would reduce the risk of constituents leaching into the ground water and further reduce potential exposure to the subsurface soil. Under Alternative 3, installation of an iron reactive wall would provide treatment of chemical constituents in the shallow water-bearing unit and further reduce potential exposure to groundwater, although the potential for such events is already very low. With the combination of existing conditions, institutional controls, focused excavation, natural attenuation, source removal actions, and downgradient groundwater treatment, Alternative 3 would have a high degree of long-term protection to human health.

The principal human exposure pathways for potential migration of chemical constituents are direct contact, inhalation of volatilized constituents, leaching to groundwater, and ingestion of groundwater. Under Alternative 3, downgradient groundwater treatment activities would provide a reduction in the groundwater constituent concentrations. However, the improvement would be of marginal consequence since there is no exposure route for human contact or ingestion under current site conditions. The source removal actions described under Alternative 2 would provide a reduction in the soil/groundwater constituent concentrations.

As previously described in Section 8.4.2, (Alternative 1), natural attenuation would provide a reduction in the groundwater constituent concentrations. As part of Alternative 1, access restrictions and deed restrictions would mitigate any potential adverse effects by preventing site access and eliminating residential land usage. As previously indicated, current conditions already address these pathways. Direct contact with constituents from the target areas has been eliminated by pavement cover and buildings, and Facility grounds are well-buffered from surrounding land uses. The pavement cover and buildings significantly reduce potential migration via the inhalation pathway, but do not completely eliminate it. Thus, there is no exposure route for human contact or ingestion, but the current exposure pathway for inhalation of volatilized constituents still exists under Alternative 2.

Potential receptors include current and future site workers. This group includes any potential on-site or construction workers operating around or in the target areas. Potential long-term exposure could occur via inhalation of volatilized constituents. Short-term exposures to site workers by direct contact or inhalation could occur during construction activities that involve trenching or other subsurface activities. These short-term exposures could be readily addressed using appropriate safety precautions and containment of the operation. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring are defined in the health and safety plan as part of the remedial action process. Site-specific training to review these procedures would be performed prior to any such activities.

Under Alternative 3, construction activities would be required for installation of the iron reactive wall. Installation of the wall could pose a health risk and a safety hazard to workers if the subsurface soil and/or groundwater is not handled properly. Excavation activities prior to wall installation would increase the potential short-term risks to human health (and the environment). To limit the dust that may be generated during grading activities, the construction area would be sprayed intermittently with a fine mist of water as warranted by the existing weather conditions. As previously described in Section 8.5.2 (Alternative 2), similar construction activities would be required for installation of the SVE/air sparging system. Since the risks to human health (and the environment) may actually be increased during implementation of the iron reactive wall and the SVE system, Alternative 3 would have a low degree of short-term effectiveness.

Protection of the Environment

The principal environmental pathways of potential constituent migration from the source and downgradient areas, respectively, include: 1) leaching from soils into the underlying shallow groundwater, and 2) flow of groundwater within the shallow water-bearing unit to Coldwater Creek.

Under Alternative 3, treatment of chemical constituents in the shallow water-bearing unit would be achieved via installation of the iron reactive wall. However, due to the low groundwater flow gradient at the site, its short-term protectiveness may be limited and the improvement may prove marginal.

As previously described in Section 7.5.2 (Alternative 2), the SVE and air sparging system would remove chemical constituents from the vadose zone of the source area to the west of Building 27. As previously described in Section 8.4.2 (Alternative 1), natural attenuation would reduce constituent concentrations in subsurface soil and shallow groundwater. However, due to the low groundwater flow gradient at the Facility, its short-term protectiveness may be limited. As an additional component of Alternative 1, groundwater monitoring would be effective in verifying that future protection of the environment is being accomplished. Thus, institutional controls would offer a high degree of long-term protectiveness of the environment. With the combination of downgradient groundwater treatment, source removal actions, focused excavation, natural attenuation, and institutional controls, Alternative 3 would provide a high degree of long-term protectiveness of the environment.

8.6.2.2 Attainment of Media Cleanup Standards

Under Alternative 3, reduction of soil/groundwater constituent concentrations within the target areas at the Facility would rely upon groundwater treatment using an iron reactive wall, SVE and air sparging methods, and natural attenuation. As previously described in Section 8.4.1, reduction of VOC concentrations via anaerobic dechlorination is already occurring at the Facility. The natural attenuation process will steadily decrease VOC concentrations in the impacted soils and groundwater. The effectiveness of this biodegradation process would continue into the future.

In addition to reducing VOC concentrations in soil and groundwater via the iron wall, SVE/air sparging methods, and natural attenuation methods, the iron wall in Alternative 3 would also enhance the potential attainment of cleanup standards for chromium.

Soil and groundwater constituent concentrations in selected areas to the west of Building 27 do not presently meet the current PROs. Based on existing soil concentrations and site conditions, attainment of soil cleanup standards could be expected within approximately 2-3 years using the SVE and air sparging methods included under Alternative 2. However, based on current groundwater concentrations present at the Facility, attainment of groundwater cleanup standards using an iron wall and natural attenuation would still require an approximate 20-30 year period under Alternative 3.

State regulatory agency approval would be required prior to implementation of Alternative 3. Regulatory approval and community acceptance for Alternative 3 are likely since the alternative is protective of human health and the environment. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.6.2.3 Source Control

Alternative 3 provides a high degree of source control by relying upon a combination of ongoing and newly implemented measures. Alternative 3 does not incorporate any additional source control measures other than those already provided in Alternative 2.

As an existing source control measure, impacted soils are currently covered by pavement and/or buildings thus eliminating any direct contact. Effectiveness of the pavement/building cover would continue into the future as long as current site conditions are maintained.

As previously described in Section 8.4.2.3 (Alternative 1), excavation of PCB-impacted soils represents an additional form of source control/removal. Excavation of PCB-impacted soils is a proven and effective method of source control.

As described in Section 8.5.2.3 (Alternative 2), SVE and air sparging would be used to effectively remove VOCs from the vadose zone of the source areas. SVE and air sparging represent proven source control technologies that are anticipated to work well given the existing Facility conditions.

Due to the 1) low horizontal flow gradient for groundwater in the shallow water-bearing unit, and 2) limited number of potential downgradient receptors, additional source control measures are not considered necessary.

8.6.2.4 Compliance with Applicable Waste Management Standards

State regulatory agency approval would be required prior to implementation of Alternative 3. Under Alternative 3, soil/groundwater constituent concentrations within the target areas at the Facility would be reduced via SVE and air sparging, focused excavation of PCB-impacted soils, and natural attenuation. In addition, downgradient groundwater concentrations would also be actively reduced using the iron wall. However, these concentrations would still need to meet site-specific cleanup standards. Due to potential air emission concerns, specific approval from the MDNR Air Pollution Control Program and/or St. Louis County Department of Health would also be required to install/operate the SVE system.

Regulatory approval and community acceptance for Alternative 3 are likely since the alternative is protective of human health and the environment. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.6.2.5 Other Factors

Long-Term Reliability and Effectiveness

Long-Term Reliability

The combination of groundwater treatment (via iron reactive barrier walls), source control (via SVE and air sparging), natural attenuation, focused excavation, and groundwater monitoring methods under Alternative 3 provide a moderate degree of reliability. Each of these technologies represents a proven and established method, although iron reactive walls provide quicker constituent reductions in more permeable geological settings. Failure of any technology within Alternative 3 would not present an immediate risk due to the limited number of receptors, the limited number of pathways for migration, and the geological characteristics of the shallow water-bearing unit. In fact, the groundwater monitoring program effectively serves as a safeguard to evaluate any potential technology failures. Uncontrollable site changes (e.g. heavy rainstorms, earthquakes, etc.) would have a potential impact on the integrity of an iron wall, and thus an effect on the long-term reliability of Alternative 3. While natural attenuation may be adversely influenced by variable subsurface conditions, the groundwater monitoring program will facilitate periodic evaluation of groundwater concentrations and any necessary modifications to the biodegradation process (nutrient addition, HRC injection, etc.).

Limited operation and maintenance efforts would be required under Alternative 3 to maintain the integrity of the iron reactive wall. As described in Section 8.5.2 (Alternative 2), periodic O&M of the

SVE/air sparging equipment and operating parameters would be required to ensure efficient operation of the system. A quarterly monitoring program of inlet and effluent vapors would also be developed to evaluate the effectiveness/acceptability of the removal effort. In addition, review of the soil vapor data would be conducted on an annual basis to substantiate the eventual shutdown of the SVE system and verify attainment of soil cleanup standards.

As previously described in Section 8.4.2 (Alternative 1), routine upkeep of the pavement cover and periodic sampling of the groundwater monitoring well network would be required. The quarterly groundwater monitoring program would facilitate periodic evaluations of constituent concentrations and any potential modifications to the biodegradation process, if needed. In addition, periodic review of the groundwater quality data would be conducted to evaluate attainment with the site-specific cleanup standards. A comprehensive O&M manual for the selected remedial alternative would address inspections and upkeep of the SVE system, as well as procedures for the groundwater monitoring program. O&M details for the selected alternative would be provided in the subsequent CMI.

Long-Term Effectiveness

Alternative 3 would possess an even higher degree of long-term effectiveness than Alternative 2 due to the added implementation of an iron reactive wall for treatment of groundwater chemical constituents. However, due to the low groundwater flow gradient at the site, its long-term effectiveness may be limited and the improvement may prove marginal.

This remedial technology would more rapidly remove constituents from the source area to the immediate west of Building 27 and therefore reduce the potential future leaching of constituents from soil into the underlying groundwater.

The effectiveness of the iron reactive wall would decrease with time as the groundwater constituents react and pass through the wall. Limited maintenance and repairs would be required to maintain its effectiveness. Based on current site conditions, an iron wall is projected to have a useful life of approximately 2-4 years. As previously described in Section 8.5.2 (Alternative 2), the effectiveness of SVE and air sparging also decreases with time as the constituents are removed from the underlying vadose zone. Based on current site conditions and the site-specific cleanup standards for soil, SVE and air sparging are projected to have a useful life of approximately 2-3 years. As previously described in

Section 8.4.2 (Alternative 1), none of the other technologies are likely to deteriorate with time. Each of the technologies under Alternative 1 would have a projected useful life that could be extended indefinitely into the future, if needed.

As previously described in Section 8.4.2 (Alternative 1), long-term effectiveness would be achieved under existing Facility conditions since the impacted soil and groundwater are currently covered, thus eliminating any direct contact. Focused excavation of PCB-impacted soils would also have a high degree of long-term effectiveness since the source material is being removed. The natural attenuation process would steadily decrease constituent concentrations in the impacted soils/groundwater into the future. Furthermore, the proposed groundwater monitoring program would provide an effective method of ensuring that downgradient constituents are not migrating off-site and impacting any potential receptors. As described in Section 8.5.2 (Alternative 2), source removal actions would offer an enhancement of long-term effectiveness. With the combination of existing conditions, natural attenuation, institutional controls, source removal, and groundwater treatment, Alternative 3 would provide a high degree of long-term effectiveness.

Reduction in Toxicity, Mobility, or Volume of Wastes

Alternative 3 would provide a moderate degree of reduction in toxicity, mobility, and volume of wastes. The iron wall implemented in Alternative 3 would serve to reduce the volume of VOCs in groundwater and the mobility of chromium in groundwater via treatment. As previously described in Section 8.5.2 (Alternative 2), SVE and air sparging would provide a significant reduction in the volume of VOCs from the source area to the immediate west of Building 27. Focused excavation of PCB-impacted soils would provide an immediate, but focused reduction in the volume of PCB constituents in the subsurface soil. However, SVE/air sparging and excavation do not represent treatment technologies. Natural attenuation would provide a gradual reduction in the toxicity and volume of groundwater constituents in the shallow water-bearing unit over time.

Short-Term Effectiveness

Under Alternative 3, significant construction activities would be required for installation of the iron reactive wall and the SVE/air sparging system. Installation requirements could pose a health risk and a safety hazard to workers if the subsurface soil is not handled properly. Excavation activities prior to iron wall and SVE manifold installation would increase the potential short-term risks to human health (and the environment). To limit the dust that may be generated during the grading activities, the construction area would be sprayed intermittently with a fine mist of water as warranted by the existing weather conditions. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring would be defined in the health and safety plan as part of the subsequent CMI.

Since the risks to human health (and the environment) may actually be increased during implementation of the iron wall and SVE system, Alternative 3 would have a low degree of short-term effectiveness.

Implementability

Installation of the iron reactive wall proposed under Alternative 3 would involve conventional construction techniques. However, due to site-specific conditions, installation of the wall would be implemented with a moderate degree of difficulty. Specific restrictions (e.g. existing sewer lines, communication lines, fire water lines, and distances from electrical poles) on the wall location may make installation more labor intensive. As described in Section 8.5.2 (Alternative 2), the SVE/air sparging system could be implemented with a moderate degree of difficulty. As described in Section 8.4.2 (Alternative 1), natural attenuation and institutional controls could be easily implemented.

Installation of the iron reactive wall under Alternative 3 utilizes conventional processes for which components can be readily obtained/completed. The necessary construction equipment and trained personnel would be provided by Boeing contractors. Specialists, construction materials, and additional equipment are readily available. As previously described in Section 8.4.2 (Alternative 1) and Section 8.5.2 (Alternative 2), natural attenuation, focused excavation, institutional controls, and source removal methods would utilize standard processes for which components are either not required or can be readily obtained. Excavation equipment and off-site disposal services could be easily secured. The necessary groundwater monitoring equipment and trained personnel could be readily provided by Boeing or its contractors.

Regulatory agency approval of the iron reactive wall would be required, as well as the SVE and air sparging system. Following regulatory approval of any wall design and the associated CMI, it is estimated that iron wall construction could be finished within an approximate 2-month period.

Following regulatory approval of the RAP, a SVE pilot test would be conducted prior to full-scale design. Due to potential air emission concerns, specific approval from the MDNR Air Pollution Control Program and/or St. Louis County Department of Health would also be required to install/operate the SVE system. Regulatory agency approval of a natural attenuation program, focused excavation activities for PCB-impacted soils, and the groundwater monitoring program would be required. The time required to obtain regulatory approval for all of the above activities could be lengthy (e.g. more than 240 days).

As a result of the potential iron wall and SVE system installation complexities, Alternative 3 would only possess a moderate degree of implementability.

Cost

The costs associated with Alternative 3 are provided in Table 8-3. The capital costs for implementation of Alternative 3 are primarily associated with the reactive iron wall and the SVE/air sparging system costs. Capital costs are estimated to be $10,585,300. Annual O&M costs of $119,400 are associated with the SVE and groundwater monitoring programs. By applying a 10.5% discount rate over a 30-year implementation period for groundwater monitoring and a 3-year implementation period for SVE/air sparging, the total present worth of Alternative 3 is estimated to be $11,452,200. A summary of the costs associated with Alternative 3 is presented in Table 8-3.

8.7 Alternative 4: Groundwater Treatment (HRC Injection), Source Removal (HRC Injection, Focused Excavation), Natural Attenuation, and Institutional Controls

Alternative 4 would consist of injecting a compound that enhances the natural biodegradation process (Hydrogen Release Compound [HRC]) to treat groundwater in the shallow water-bearing unit to the east of Building 27. The source removal actions described for Alternative 2 in Section 8.5 would also be achieved using HRC injection methods. The natural attenuation, focused excavation and institutional controls described for Alternative 1 in Section 8.4 would also be included within Alternative 4.

8.7.1 Detailed Description

The major aspect of Alternative 4 would involve the injection of HRC to expedite the natural biodegradation process for impacted subsurface soils and groundwater at the target areas of the Facility. HRC is a proprietary polylactate ester of Regenesis, Inc. that is specially formulated for slow release of lactic acid upon contact with water in the subsurface environment. Remediation of soil and groundwater by HRC injection involves the installation of numerous injection points throughout the contaminated zone. This process involves the percolation or injection of water mixed with HRC compound to greatly enhance the reductive dechlorination process. The dechlorination process ultimately results in production of non-toxic compounds such as ethane or ethene.

Chlorinated solvents undergo biodegradation through three different pathways: 1) use as an electron acceptor (reductive dechlorination); 2) use as an electron donor (primary substrate); 3) co-metabolism where degradation of the chlorinated solvent provides no benefit to the microorganism but is simply fortuitous. In general, biodegradation of chlorinated solvents is an electron-donor-limited process.

The generalized process of biodegradation of chlorinated solvents begins in the saturated subsurface where native/anthropogenic carbon is utilized as an electron donor, and dissolved oxygen is utilized first for the prime electron acceptor. Once the dissolved oxygen is depleted, anaerobic microorganisms typically utilize additional available electron acceptors in the following order: nitrate, ferric iron hydroxide, sulfate, and carbon dioxide. In the absence of nitrate and dissolved oxygen, chlorinated solvents compete with other electron acceptors and donors, especially sulfate and carbon dioxide. By looking at the spatial distribution and concentrations of electron acceptors and donors, the mechanism(s) and rates of biodegradation can be assessed.

The most important process for the natural biodegradation of chlorinated solvents is reductive dechlorination. The chlorinated solvent is utilized as an electron acceptor, and a chlorine atom is removed and replaced with a hydrogen atom. Because chlorinated solvents are utilized as electron acceptors during reductive dechlorination, an appropriate carbon source is required for microbial growth to occur. Reductive dechlorination has been demonstrated under nitrate- and sulfate-reducing conditions, but the highest rates of biodegradation occur during methanogenic conditions.

Under Alternative 4, HRC would be injected in multiple borings to remediate the source area to the west of Building 27. In addition, HRC would also be injected to treat downgradient groundwater constituents to the east of Building 27. HRC would not only treat the organic constituents of concern, but address metal issues by precipitating/stabilizing chromium along the southeast corner of Bldg 27.

Since HRC injection represents a relatively new technology, a pilot study would initially be performed at the Facility to verify its effectiveness for site-specific conditions. The objective of the pilot study would be to demonstrate that an HRC-based remediation program will reduce the concentrations of TCE and the associated degradation products in soil and groundwater. Regulatory approval and an injection permit from the MDNR Water Pollution Control Program would be required prior to initiating the pilot study. The HRC pilot study would then be conducted within the target area to the immediate west of Building 27 to evaluate enhanced biodegradation rates, reductive constituent concentrations, and other design parameters related to HRC injection.

Degradation rates are highest under anaerobic conditions and generally involve multi-step biological activity. HRC would promote anaerobic bioremediation of groundwater by slowly releasing lactic acid that is metabolized by indigenous anaerobic microbes. Metabolism of lactic acid produces hydrogen that is used by reductive dehalogenating microbes that are capable of dechlorinating TCE and other chlorinated hydrocarbons. The process is controlled by providing a long-lasting, time-released source of lactic acid to keep the groundwater environment within specific anaerobic conditions. This slow, controlled release of hydrogen limits the activity of methanogenic microbes normally assoicated with highly anaerobic conditions. The HRC delivery method is important in ensuring that a sufficient area can be addressed. Direct push technology would be used as the delivery method for the pilot study.

The pilot study would be conducted within a 25-ft by 25-ft (625 square feet) area in the immediate vicinity of MW-3 near the Recycle Center on the west side of Building 27. Results from the Phase 2A/2B investigation efforts indicated that this area generally contained the highest VOC concentrations in soil and groundwater at the Facility. HRC would be injected into shallow groundwater from a depth of 8-28 ft bls; depth to groundwater in this area is approximately 8-12 ft bls. Nine (9) HRC injection points would be used at an application rate of 6.7 pounds of HRC per linear foot (e.g. 1,206 pounds of HRC would be injected). The injection points would be placed in a grid pattern with 10-ft spacings between the injection points. Two new monitoring wells (upgradient and downgradient) would be installed to collect groundwater data for the pilot study. On-site HRC injection activities would require an approximate 2-day period.

To evaluate the effectiveness of the HRC pilot study, groundwater would be sampled using low flow sampling techniques. Analytical constituents would include redox potential, dissolved oxygen, nitrates, sulfates, metabolic acids, permanent gases, and ferrous iron. This data would be collected on a monthly basis over a 9-month period. It is anticipated that the analytical groundwater data collected during the pilot test will demonstrate the absence of any injected HRC material by the end of the pilot study. Soil samples would also be collected after a 6-9 month period to provide data regarding effectivness of the technology in the unsaturated unit. Updates will be provided to the MDNR every three months.

Based on successful completion of the 9-month HRC pilot study, full-scale HRC applications to remediate the source area and downgradient groundwater constituents would be designed/implemented. Injection permits would need to be obtained from the MDNR Water Pollution Control Program prior to implementation of any pilot tests or full-scale applications.

Natural attenuation, focused excavation, and institutional controls described in Section 8.4.1 (Alternative 1) would also apply to Alternative 4. If selected as the remedial alternative for the Facility, additional detail for Alternative 4 would be provided in the CMI.

8.7.2 Assessment

The results of assessing Alternative 4 against the five evaluation standards are presented below.

8.7.2.1 Protection of Human Health and the Environment

Protection of Human Health

The only potential current human exposure route associated with subsurface soils or groundwater from the target areas at the Facility is via inhalation of volatilized constituents through concrete floor slabs or pavement cover. Since utilization of the Facility is expected to remain the same in future years, it is expected that the existing protection level of human health would be maintained. However, implementation of Alternative 4 would ensure that levels of protection are improved in the future.

Existing pavement and building cover would reduce the amount of water infiltration into the subsurface soil. As previously described in Section 8.4.2 (Alternative 1), institutional controls would further ensure the continued protection of human health into the future by minimizing Facility access and controlling future land usage. Under Alternative 4, source removal and downgradient groundwater treatment via HRC injection would reduce the risk of constituents leaching into the groundwater and further reduce potential exposure to subsurface soils and groundwater, although the potential for such events is already very low. HRC injection would also provide treatment of chemical constituents in the shallow water-bearing unit. With the combination of existing conditions, focused excavation, natural attenuation, institutional controls, source removal and downgradient groundwater treatment via HRC injection, Alternative 4 would have a high degree of long-term protection to human health.

The principal human exposure pathways for potential migration of chemical constituents are direct contact, inhalation of volatilized constituents, leaching to groundwater, and ingestion of groundwater. Under Alternative 4, source removal actions and downgradient groundwater treatment activities would provide a reduction in the soil/groundwater constituent concentrations. However, the improvement would be of marginal consequence since there is no exposure route for human contact or ingestion under current site conditions.

As previously described in Section 8.4.2, (Alternative 1), focused excavation of PCB-impacted soils and natural attenuation would provide a reduction in the soil/groundwater constituent concentrations. As part of Alternative 1, access restrictions and deed restrictions would mitigate any potential adverse effects by preventing site access and eliminating residential land usage. As previously indicated, current conditions already address these pathways. Direct contact with constituents from the target areas has been eliminated by pavement cover and buildings, and Facility grounds are well-buffered from surrounding land uses. The pavement cover and buildings significantly reduce potential migration via the inhalation pathway, but do not completely eliminate it. Thus, there is no exposure route for human contact or ingestion, but the current exposure pathway for inhalation of volatilized constituents still exists under Alternative 4.

Potential receptors include current and future site workers. This group includes any potential on-site or construction workers operating around or in the target areas. Potential long-term exposure could occur via inhalation of volatilized constituents. Short-term exposures to site workers by direct contact or inhalation could occur during construction activities that involve excavation or other subsurface activities. These short-term exposures could be readily addressed using appropriate safety precautions and containment of the operation. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring are defined in the health and safety plan as part of the remedial action process. Site-specific training to review these procedures would be performed prior to any such activities.

Under Alternative 4, only limited construction activities would be required to implement the HRC injection program and excavate PCB-impacted soils. Since the risks to human health would only be marginally increased during implementation of this alternative, Alternative 4 would have a high degree of short-term effectiveness.

Protection of the Environment

The principal environmental pathways of potential constituent migration from the source and downgradient areas, respectively, include: 1) leaching from soils into the underlying shallow groundwater, and 2) flow of groundwater within the shallow water-bearing unit to Coldwater Creek. Under Alternative 4, treatment of chemical constituents in the source area and the shallow water-bearing unit would be achieved via implementation of the HRC injection program.

As previously described in Section 8.4.2 (Alternative 1), natural attenuation would reduce constituent concentrations in subsurface soil and shallow groundwater. However, due to the low groundwater flow gradient at the Facility, its short-term protectiveness may be limited. As an additional component of Alternative 1, groundwater monitoring would be effective in verifying that future protection of the environment is being accomplished. Thus, institutional controls would offer a high degree of long-term protectiveness of the environment. With the combination of natural attenuation, institutional controls, focused excavation, source removal and downgradient groundwater treatment via HRC injection, Alternative 4 would provide a high degree of long-term protectiveness of the environment.

8.7.2.2 Attainment of Media Cleanup Standards

Under Alternative 4, reduction of soil/groundwater constituent concentrations within the target areas at the Facility would rely upon groundwater treatment using an HRC injection program, focused excavation of PCB-impacted soils, and natural attenuation. As previously described in Section 8.4.1, reduction of VOC concentrations via anaerobic dechlorination is already occurring at the Facility. The natural attenuation process will steadily decrease VOC concentrations in the impacted soils and groundwater. The effectiveness of this biodegradation process would continue into the future.

In addition to reducing VOC concentrations in soil and groundwater via the HRC injection program and natural attenuation methods, Alternative 4 would also enhance the potential attainment of cleanup standards for chromium and PCBs.

Soil and groundwater constituent concentrations in selected areas to the west of Building 27 do not presently meet the current PROs. Based on existing soil/groundwater concentrations and site conditions, attainment of soil and groundwater cleanup standards could be expected within approximately 3-5 years using the HRC injection program included under Alternative 4.

State regulatory agency approval would be required prior to implementation of Alternative 4. Regulatory approval and community acceptance for Alternative 4 are likely since the alternative is protective of human health and the environment. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP.

8.7.2.3 Source Control

Alternative 4 provides a high degree of source control by relying upon a combination of ongoing and newly implemented measures.

As an existing source control measure, impacted soils are currently covered by pavement and/or buildings thus eliminating any direct contact. Effectiveness of the pavement/building cover would continue into the future as long as current site conditions are maintained.

Under Alternative 4, HRC injection would be used to treat/reduce VOCs/PCBs in soil and shallow groundwater. In addition, HRC injection would reduce the mobility of chromium in groundwater. HRC injection represents a recently developed technology that would require pilot testing at the Facility to evaluate its effectiveness for the site-specific conditions.

As previously described in Section 8.4.2.3 (Alternative 1), excavation of PCB-impacted soils represents an additional form of source control/removal. Excavation of PCB-impacted soils is a proven and effective method of source control.

Due to the 1) low horizontal flow gradient for groundwater in the shallow water-bearing unit, and 2) limited number of potential downgradient receptors, additional source control measures are not considered necessary.

8.7.2.4 Compliance with Applicable Waste Management Standards

State regulatory agency approval (including an injection permit from the MDNR Water Pollution Control Program) would be required prior to implementation of Alternative 4. Under Alternative 4, soil/groundwater constituent concentrations within the source area to the west of Building 27 would be reduced via HRC injection, focused excavation of PCB-impacted soils, and natural attenuation. In addition, downgradient groundwater concentrations would also be actively reduced using HRC injection. However, soil and groundwater constituent concentrations would still need to meet site-specific cleanup standards.

Regulatory approval and community acceptance for Alternative 4 are likely since the alternative is protective of human health and the environment. However, final assessment of regulatory acceptance cannot be made until after MDNR comments are received following their review of the RAP. Alternative 4 represents an effective approach for remediating the target areas of the Facility in a very aggressive timeframe.

8.7.2.5 Other Factors

Long-Term Reliability and Effectiveness

Long-Term Reliability

The combination of groundwater treatment (via HRC injection), source removal (via HRC injection and focused excavation), natural attenuation, focused excavation, and groundwater monitoring methods under Alternative 4 provide a moderate degree of reliability. With the exception of HRC injection, each of these technologies represents a proven and established method. Effectiveness of the HRC injection program would need to be demonstrated by completing a pilot test study at the Facility. Failure of any technology within Alternative 4 would not present an immediate risk due to the limited number of receptors, the limited number of pathways for migration, and the geological characteristics of the shallow water-bearing unit. In fact, the groundwater monitoring program effectively serves as a safeguard to evaluate any potential technology failures. Uncontrollable site changes (e.g. heavy rainstorms, earthquakes, etc.) would have a minimal impact on the long-term reliability of Alternative 4. While natural attenuation may be adversely influenced by variable subsurface conditions, the groundwater monitoring program will facilitate periodic evaluation of groundwater concentrations and any necessary modifications to the biodegradation process (nutrient addition, HRC injection, etc.).

Limited operational efforts would be required under Alternative 4 to ensure efficient operation of the HRC injection program. As previously described in Section 8.4.2 (Alternative 1), routine upkeep of the pavement cover and periodic sampling of the groundwater monitoring well network would be required. The quarterly groundwater monitoring program would facilitate periodic evaluations of constituent concentrations and any potential modifications to the biodegradation process, if needed. In addition, review of soil/groundwater analytical data would be conducted on an annual basis to substantiate the eventual completion of the HRC injection program and evaluate attainment with the site-specific cleanup standards. A comprehensive O&M manual for the selected remedial alternative would address procedures for the groundwater monitoring program. O&M details for the selected alternative would be provided in the subsequent CMI.

Long-Term Effectiveness

Alternative 4 would possess a high degree of long-term effectiveness due to the implementation of HRC injection to expedite biodegradation/treatment of the groundwater chemical constituents. While various site conditions and HRC case studies indicate that this remedial technology is appropriate for the site, a pilot test will be conducted to verify and demonstrate its effectiveness at the Facility. Due to the low groundwater flow gradient at the site, its long-term effectiveness may be dependent upon the ability to periodically track and shrink the extent of the downgradient plume.

This remedial technology would more rapidly remove constituents from the source area to the immediate west of Building 27 and therefore reduce the potential future leaching of constituents from soil into the underlying groundwater.

The effectiveness of each HRC injection round would decrease with time as the biodegradation process proceeds in the subsurface soils/groundwater. No maintenance or repairs would be required to maintain its effectiveness. Based on current site conditions, the initial HRC injection round is projected to have a useful life of approximately 1-2 years. As previously described in Section 8.4.2 (Alternative 1), none of the other technologies are likely to deteriorate with time. Each of the technologies under Alternative 1 would have a projected useful life that could be extended indefinitely into the future, if needed.

As previously described in Section 8.4.2 (Alternative 1), long-term effectiveness would be achieved under existing Facility conditions since the impacted soil and groundwater are currently covered, thus eliminating any direct contact. Focused excavation of PCB-impacted soils would also have a high degree of long-term effectiveness since the source material is being removed. The natural attenuation process would steadily decrease constituent concentrations in the impacted soils/groundwater into the future. Furthermore, the proposed groundwater monitoring program would provide an effective method of ensuring that downgradient constituents are not migrating off-site and impacting any potential receptors. Source removal/treatment via HRC injection would offer an enhancement of long-term effectiveness. With the combination of existing conditions, natural attenuation, institutional controls, source removal (HRC injection), and groundwater treatment (HRC injection), Alternative 4 would provide a high degree of long-term effectiveness.

Reduction in Toxicity, Mobility, or Volume of Wastes

Alternative 4 would provide a moderate degree of reduction in toxicity, mobility, and volume of wastes. The HRC injection program implemented in Alternative 4 would serve to reduce the volume of VOCs in soil/groundwater and the mobility of chromium in groundwater via treatment. Focused excavation of PCB-impacted soils would provide an immediate, but focused reduction in the volume of PCB constituents in the subsurface soil. Natural attenuation would provide a gradual reduction in the toxicity and volume of groundwater constituents in the shallow water-bearing unit over time.

Short-Term Effectiveness

Under Alternative 4, only limited construction activities would be required for implementation of the HRC injection program. Installation requirements could pose a health risk and a safety hazard to workers if the subsurface soil is not handled properly. Excavation activities would increase the potential short-term risks to human health (and the environment). To limit the dust that may be generated during the grading activities, the construction area would be sprayed intermittently with a fine mist of water as warranted by the existing weather conditions. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring would be defined in the health and safety plan as part of the subsequent CMI.

Since the risks to human health (and the environment) would only be marginally increased during implementation of the HRC injection program, Alternative 4 would have a high degree of short-term effectiveness.

Implementability

Injection of HRC proposed under Alternative 4 involves conventional well construction techniques. Specific restrictions (e.g. existing sewer lines, communication lines, fire water lines, and distances from electrical poles) regarding the exact injection point locations may add minor implementation delays. However, completion of the HRC injection points should be relatively easy to implement. As described in Section 8.4.2 (Alternative 1), natural attenuation and institutional controls could be easily implemented.

The HRC injection process proposed under Alternative 4 utilizes conventional processes for which components can be readily obtained/completed. The necessary construction equipment and trained personnel would be provided by Boeing contractors. Specialists, construction materials, and additional equipment are readily available. As previously described in Section 8.4.2 (Alternative 1), natural attenuation, focused excavation, and institutional control methods would utilize standard processes for which components are either not required or can be readily obtained. Excavation equipment and off-site disposal services could be easily secured. The necessary groundwater monitoring equipment and trained personnel could be readily provided by Boeing or its contractors.

Regulatory agency approval and an underground injection permit would be required prior to implementation of the HRC injection program. Following regulatory approval of the RAP, an approximate 9-month HRC injection pilot test would be conducted prior to full-scale design. Following regulatory approval of the HRC program design and the associated CMI, it is estimated that the initial HRC injection program could be completed within an approximate 2-month period. Regulatory agency approval of a natural attenuation program, focused excavation activities for PCB-impacted soils, and the groundwater monitoring program would be required. The time required to obtain regulatory approval for all of the above activities could be lengthy (e.g. more than 240 days).

As a result, Alternative 4 would possess a moderate degree of implementability.

Cost

The costs associated with Alternative 4 are provided in Table 8-4. The capital costs for implementation of Alternative 4 are primarily associated with the HRC injection program costs. Capital costs are estimated to be $4,231,800. Annual O&M costs of $139,900 are associated with the groundwater monitoring program. The total present worth of Alternative 4 is estimated to be $4,934,300. Results from the HRC pilot study will help to more accurately define the required number of injection points and HRC product volumes. A summary of the costs associated with Alternative 4 is presented in Table 8-4.

Table 8-1 Estimated Costs for Alternative 1 (Natural Attenuation, Focused Excavation, and Institutional Controls)
Boeing RAP, St. Louis, Missouri Facility

Task/Description	Quantity	Unit Cost		Total Cost	
CAPITAL COSTS					
SOURCE REMOVAL COSTS (Focused Excavation)					
Soil Excavation, Tranportation, & Disposal			L.S.	280,000	Localized PCB impacts near RC-
INSTITUTIONAL CONTROLS COSTS (Access Restrictions)					
Fencing/Security Enhancements			L.S.	100,000	
Subtotal				380,000	
Contingency				57,000	15 % Assumed
Construction Cost				437,000	
Total Capital Cost (Institutional Controls)				437,000	
TOTAL CAPITAL COSTS				**437,000**	
ANNUAL O&M COSTS					
ANNUAL OPERATING COSTS (INST. CONTROLS)					
GROUNDWATER MONITORING					
Sample Collection	4	$7,000	/event	28,000	
Sample Analysis (VOCs)	88	$110	/sple	9,700	(20 well sples+2 QA quarterly)
Sample Analysis (Biodegrad)	12	$500	/sple	6,000	(10 well sples+2 QA annually)
Data Review & Reporting	4	$8,000	/event	32,000	
Subtotal				75,700	
Contingency				11,300	15 % Assumed
Total Annual O&M Cost (Institutional Controls) (30-yr life)				87,000	
Present Worth of O&M Costs				**787,200**	**10.5% rate of return**
TOTAL PRESENT WORTH of ALTERNATIVE 1				**1,224,200**	

Table 8-3 Estimated Costs for Alternative 3 (Downgradient GW Treatment [Iron Reactive Barrier Wall], Source Removàl [SVE and Air Sparging], Natural Attenuation, and Institutional Controls), Boeing RAP, St. Louis Facility

Task/Description	Quantity	Unit Cost		Total Cost	
CAPITAL COSTS					
SOURCE REMOVAL COSTS (SVE and Air Sparging; Focused Excavation)					
Site Preparation			L.S.	20,000	
Mobilization/Demob.			L.S.	20,000	
Extraction Well Install. (4)	80	$75	/LF	6,000	
Extraction Trench Install. (4)	800	$30	/LF	24,000	
Sparging Well Install. (400)	6,000	$75	/LF	450,000	
SVE Building Enclosure	2	$15,000	/ea	30,000	
Blower	4	$9,000	/ea	36,000	
Separator	2	$1,500	/ea	3,000	
Piping, Fittings, Valves			L.S.	1,500,000	
Instrumentation			L.S.	30,000	
Electrical			L.S.	40,000	
Installation			L.S.	250,000	
Start-up Services			L.S.	100,000	
Soil Excavation, Tranportation, & Disposal			L.S.	280,000	Localized PCB impacts near RC-2
Subtotal				2,789,000	
Contingency				418,400	15 % Assumed
Construction Cost				3,207,400	
Engineering				481,100	15 % of Const. Cost
Health & Safety				320,800	10 % of Const. Cost
Total Capital Cost (SVE and Air Sparging; Focused Excavation)				4,009,300	
GROUNDWATER TREATMENT COSTS (Iron Reactive Barrier Wall)					
Iron Reactive Barrier Wall	700	$9,230	/LF	6,461,000	
Total Capital Cost (Iron Reactive Barrier Wall)				6,461,000	
INSTITUTIONAL CONTROLS COSTS (Access Restrictions)					
Fencing/Security Enhancements			L.S.	100,000	
Subtotal				100,000	
Contingency				15,000	15 % Assumed
Construction Cost				115,000	
Total Capital Cost (Institutional Controls)				115,000	
TOTAL CAPITAL COSTS				**10,585,300**	
ANNUAL O&M COSTS					
ANNUAL OPERATING COSTS (GW Monitoring)					
Sample Collection	4	$7,000	/event	28,000	
Sample Analysis (VOCs)	88	$110	/sple	9,700	(20 well sples+2 QA qtrly)
Sample Analysis (Biodegrad)	12	$500	/sple	6,000	(10 well sples+2 QA annually)
Data Review & Reporting	4	$8,000	/event	32,000	
Subtotal				75,700	
Contingency				11,300	15 % Assumed
Total Annual O&M Cost (GW Monitoring) (30-yr life)				87,000	
ANNUAL OPERATING COSTS (SVE and Air Sparging)					
Electricity Costs		$5,000	L.S.	5,000	
Maintenance	4	$2,000	/qtr.	8,000	
Sample Collection	2	$3,000	/event	6,000	
Sample Analysis	14	$300	/sple	4,200	(12 samples+2 QA)
Administration		$5,000	L.S.	5,000	
Subtotal				28,200	
Contingency				4,200	15 % Assumed
Total Annual O&M Cost (SVE and Air Sparging) (3-yr life)				32,400	
Present Worth of O&M Costs				866,900	10.5% rate of return
TOTAL PRESENT WORTH of ALTERNATIVE 3				**11,452,200**	

Table 8-4 Estimated Costs for Alternative 4 (Downgradient GW Treatment [HRC Injection], Source Removal [HRC Injection; Focused Excavation], Natural Attenuation, and Institutional Controls), Boeing RAP, St. Louis, Missouri Facility

Task/Description	Quantity	Unit Cost		Total Cost	
CAPITAL COSTS					
SOURCE REMOVAL / GROUNDWATER TREATMENT COSTS (HRC Injection)					
Soil Excavation, Transportation, & Disposal			L.S.	282,000	Localized PCB impacts near RC-2
HRC Pilot Test			L.S.	40,000	
Site Preparation			L.S.	50,000	
Mobilization/Demob.			L.S.	50,000	
Injection Point Install.(125K sq.ft.)	1,390	$200	/pt	278,000	10' center, $1500/day, 7.5 points/day
HRC Reagent	125,100	$7	/lb	875,700	
Start-up Services			L.S.	50,000	
HRC Source Reapplication (2x)			L.S.	778,700	Assume reduced re-application rate.
HRC "Barrier Wall" Reapplication (4x)			L.S.	461,500	Assume equiv re-application rate.
	Subtotal			2,865,900	
	Contingency			429,900	15 % Assumed
	Construction Cost			3,295,800	
	Project Management			494,400	15 % of Const. Cost
	G & A			329,600	10 % of Const. Cost
Total Capital Cost (HRC Injection; Focused Excavation)				4,119,800	
INSTITUTIONAL CONTROLS COSTS (Access Restrictions)					
Fencing/Security Enhancements			L.S.	100,000	
	Subtotal			100,000	
	Contingency			15,000	15 % Assumed
	Construction Cost			115,000	
Total Capital Cost (Institutional Controls)				115,000	
TOTAL CAPITAL COSTS				4,234,800	
ANNUAL O&M COSTS					
ANNUAL OPERATING COSTS (GW Monitoring)					
Sample Collection	4	$7,000	/event	28,000	
Sample Analysis (VOCs)	88	$110	/sple	9,700	(20 well sples+2 QA quarterly)
Sample Analysis (HRC-Related)	88	$500	/sple	44,000	(20 well sples+2 QA quarterly)
Data Review & Reporting	4	$10,000	/event	40,000	
	Subtotal			121,700	
	Contingency			18,200	15 % Assumed
Total Annual O&M Cost (GW Monitoring) (5-yr life)				139,900	
Total Operating Costs				699,500	
TOTAL PRESENT WORTH of ALTERNATIVE 4				4,934,300	

9.0 Selection of Remedial Action Alternative

As a result of the alternative evaluation process performed in Section 8, Alternative 4 was selected as the remedial action alternative. This alternative meets the standards for protection of human health and the environment. It will also provide long-term and short-term effectiveness in addressing potential concerns associated with the target areas. Alternative 4 can be implemented without excessive difficulty or disruption to existing/future production activities at the Facility.

Alternative 4 is protective of human health and the environment. Access restrictions will be effective in preventing unauthorized personnel from entering the Facility, thus, minimizing the potential for any inadvertent exposures to the soil/groundwater. Groundwater monitoring will provide an effective means of verifying groundwater quality in the future. Treatment of soil/groundwater constituents via HRC injection will ensure protection of human health and the environment.

This alternative provides a high degree of long-term effectiveness for the Facility. Treatment of soil/groundwater constituents via HRC injection will provide an effective method of treatment and minimize potential migration of soil or groundwater constituents to any off-site receptors. The groundwater monitoring program will verify the effectiveness and completion of this treatment process. Upkeep and periodic maintenance of the existing pavement/building cover will ensure that potential exposure to subsurface soils and infiltration into the underlying shallow water-bearing unit are minimized. In this manner, effectiveness of the remedy will be verified, residual risks will be acceptable, and remedial action objectives will be met.

Alternative 4 provides a high degree of short-term effectiveness. Community health and safety can be preserved while reducing long-term site effects on human health and the environment. Short-term exposures to site workers involving potential future construction activities can be minimized using conventional methods. Safety procedures to address personal protective equipment (PPE), respiratory protective equipment (RPE), decontamination, and medical surveillance monitoring will be defined in the health and safety plan to be developed as part of the remedial action design. Site-specific training to review these procedures will be performed prior to implementation of the remedial action alternative.

Downgradient groundwater treatment via HRC injection, source removal actions, natural attenuation, and institutional control measures (including groundwater monitoring and access restrictions) that are proposed under Alternative 4 can be implemented without difficulty. The HRC pilot study will be used to demonstrate effectiveness of this technology and support design details in the CMI. Each of the remaining remedial measures under Alternative 4 represents a proven and available technology.

Alternative 4 is also a cost-effective remedy when compared against the other investigated alternatives. It provides suitable long-term effectiveness, short-term effectiveness, and can be implemented at a lower cost than other alternatives.

9.1 Conclusion

When considering all factors, Alternative 4 meets the statutory requirements for remedy selection, meets the remedial action objectives, protects human health and the environment, and is compatible with the overall concerns of the community and of The Boeing Company while being cost-effective when compared with other alternatives. For these reasons, Alternative 4 has been selected for further detailed development in the CMI and subsequent implementation at the Boeing Facility.

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